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CONTRACT NO. N62742-81-C-0006

A-E SERVICES TO PERFORM A CATHODIC PROTECTION SURVEY OF THE BULK FUEL TERMINALS AT N.S.C., PEARL HARBOR, HAWAII

JUNE 1982

REGISTERED PROFESSIONAL ENGINEER
HEAVEN TSO
NO CR746
CORROSION
STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER
EVAN L. JAMES
NO. CR 606
CORROSION
STATE OF CALIFORNIA

H. Tso, Chief Engineer &
Project Manager

E.L. James, President

PACIFIC CORROSION RESEARCH, INC.
5481 B COMMERCIAL DRIVE
HUNTINGTON BEACH, CALIFORNIA 92649

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GENERAL SUMMARY

GENERAL SUMMARY

1. Purpose:

A. The purpose of this corrosion survey was to inspect and checkout the existing cathodic protection systems of the underground metallic fuel lines and tanks at the Bulk Fuel Terminal, Naval Supply Center, Pearl Harbor, Hawaii.

B. The corrosion survey was conducted from August 1981 to May of 1982.

C. The corrosion survey was conducted on the following fuel tanks and fuel lines under Contract N62742-81-C-0006.

(1) POL Lines -

a. Outside the Pearl Harbor Complex.
b. Inside the Pearl Harbor Complex.

(2) POL Tanks -

a. Pearl City Tank Farm. (NSC)
b. Upper Tank Farm. (NSC)
c. Middle Tank Farm. (NSC)
d. Lower Tank Farm. (NSC)
e. Ballast Tank 355. (Red Hill)
f. Water Tank at Stilling Basin. (Red Hill)

D. The corrosion evaluation survey was conducted on the following fuel lines under Contract N62742-81-C-0006/P00002.

(1) 16", 18" & 32" POL Lines in lower tunnel from Red Hill Storage Tanks to the Pearl Harbor Naval Base.

2. Findings:

A. Existing Cathodic Protection Systems.

(1) Impressed Current System - This system consists of seven rectifiers and associated anode beds.

a. Rectifier #3 (Oil Cooled) - Functioning properly.

b. Rectifier #5 (Oil Cooled) - Not functioning properly.

c. Rectifier #8 (Oil Cooled) - Not functioning properly.

d. Rectifier #9 (Air Cooled) - Not functioning properly.

e. Rectifier #11 (Oil Cooled) - Functioning properly.

f. Rectifier #12 (Air Cooled) - Not functioning properly.

g. Rectifier #13 (Air Cooled) - Functioning properly.

(2) Sacrificial Anode System - A total of 28 sacrificial anode beds were installed in the past. Seventeen anode beds were located and tested during this survey. Only twelve were found to be operating properly.

B. Protective Potential Level of POL Lines and Tanks.

(1) POL Lines -

a. Outside of the Pearl Harbor Complex approximately 95% of POL lines are not at a protective potential level.

b. Inside the Pearl Harbor Complex, none of the POL lines are at a protective potential level.

(2) POL Tanks -

a. Pearl City Tank Farm - Only Tank #1 (S93) and Tank #B-1 (S775) are at a protective potential level.

b. Upper Tank Farm (NSC) - Not at a protective potential level.

c. Middle Tank Farm (NSC) - Not at a protective potential level.

d. Lower Tank Farm (NSC) - Not at a protective potential level.

e. Ballast Tank 355 (Red Hill) - Not at a protective potential level.

f. Water Tank at Stilling Basin (Red Hill) - Not at a protective potential level.

C. Inspection of Three (3) POL lines in the Lower Tunnel from Red Hill Storage Tanks to the Pearl Harbor Naval Base.

The external surface of all three (3) POL pipelines in the Red Hill Tunnel are experiencing some type of coating damage and corrosive attack, due to ground water leaks in the 6" gunite coating of the tunnel.

Several of the steel structural support members are also experiencing severe corrosion due to water leakage in the tunnel.

The constant dripping of ground water and the high evaporation rate has caused concentrated corrosion cells on the exterior of the pipeline.

3. Recommendations:

A. It is recommended that a new overall series of cathodic protection systems be designed and installed at the Bulk Fuel Terminals, NSC, Pearl Harbor, Hawaii. The recommended systems will consist of the following materials and installations:

(1) Replace the existing seven rectifiers, R-3, R-5, R-8, R-9, R-11, R-12 & R-13 with seven new oil cooled rectifiers with a D.C. current output rating from 30 A. to 60 A.

(2) Install eighteen (18) new oil cooled rectifiers with a D.C. current output rating from 40 A. to 60 A.

(3) Install one-hundred-sixty-six (166) 4'x40" graphite anodes, twenty-four (24) 4"x80" graphite anodes, eighty seven (87) 4½"x60" high silicon iron anodes, twenty (20)

4-3/4"x84" high silicon iron tubular anodes, one-hundred twenty-seven (127) 50 lb. prepackaged magnesium anodes, eleven (11) 4"x4"x60", 60 lb. magnesium anodes, ten (10) 4"x4"x36", 159 lb. zinc anodes and twenty-seven (27) test boxes.

(4) Install thirty-two (32) resistance bond stations between the POL lines and other metallic lines.

(5) Install continuity bonds across each joint on the cast iron water mains in all tanks and in the areas west of VC-1 and VC-2.

The recommended systems will provide protection for a period in excess of twenty years.

B. It is recommended that the coating of the above ground POL lines be inspected at least twice a year and repaired as necessary.

C. If any new POL lines are installed and any existing POL lines are to be replaced in the future, it is recommended that X-Tru-Coated steel pipe be used and then be considered for cathodic protection. A sample specification of Polyethylene Plastic Coated (X-tru-Coated) steel pipe is provided and may be found in the appendix of this report.

D. If construction funds are approved in phases, it is suggested that the systems should be corrected in the following priorities:

1. Section B-6
2. Section A-4
3. Section A-2
4. Section A-5
5. Section A-3
6. Section C-2
7. Section C-1
8. Section C-3
9. Section C-4
10. Section B-1
11. Section B-8
12. Section B-3
13. Section A-1
14. Section B-5
15. Section B-7
16. Section C-5
17. Section B-4
18. Section B-2
19. Section B-9
20. Section B-10

E. <u>Lines in the Lower Tunnel from Red Hill Storage Tanks to the Pearl Harbor Naval Base.</u>

The corrosion damaged areas on three (3) POL pipelines should be re-coated, as recommended. The annular spaces, at the 6" bulkhead/wall penetration in the new tank area should be repaired, as recommended. The existing galvanized sheet steel "umbrellas" should be replaced with non-metallic materials. A structural/civil engineer should determine to what extend corrosion damage has effected the structural support members in the tunnel. A corrosion evaluation survey should be performed on the 32" Ø water line in the tunnel. Because of the leaks, a corrosion survey should be performed on the twenty (20) underground storage tankliners and associated underground piping in the storage tank area.

NOTES:

1. Locations of pipe-to-soil potentials, soil resistivity measurements, current tests, existing cathodic protection systems and newly recommended cathodic protection systems are shown on Pacific Corrosion Research drawings found at the end of each section.

2. Locations of soil resistivity measurements and newly recommended cathodic protection systems are also shown on the Navy supplied drawings titled "Naval Complex Pearl Harbor - POL Lines".

   The original full size, mylar copies of these drawings were returned to Mr. Fred Nakamura, Code 102, Naval Facilities Engineering Command, Pearl Harbor, Hawaii.

   Included with this report are 8½"x11" reductions of these drawings, which were supplied by Mr. Fred Nakamura.

3. Locations of each specific POL pipeline or fuel tank sections are shown on full size color coded drawings included with this report.

SECTION I

INTRODUCTION

CORROSIVITY SURVEY BULK FUEL TERMINALS

N.S.C. PEARL HARBOR, HAWAII

CONTRACT NO. N62742-81-C-0006

SECTION I - INTRODUCTION

A corrosion survey was conducted at the Bulk Fuel Terminals, Naval Supply Center, Pearl Harbor, Hawaii, upon authorization from Captain A. E. Smith, CEC, Contracting Officer, Pacific Division, U. S. Naval Facilities Engineering Command, Pearl Harbor, Hawaii. The authorization contract N62742-81-C-0006 was dated July 13, 1981.

Engineers from Pacific Corrosion Research, Inc. reported to Mr. Fred Nakamura, Project Design Engineer, and Mr. Jim Gammon, Superintendent of Fuel Department, Code 102, on August 14, 1981, to start the field portion of the project.

The survey consisted of the following work:

A. Obtain available drawings from Naval Base Personnel. These drawings were reviewed and studied to determine the structures and lines to be considered in the survey.

B. Soil resistivity measurements were obtained at representative locations at approximately 200' intervals along the "on base" lines. "Off base" lines resistivity measurements were obtained along the fuel lines at approximately 500' intervals. Soil resistivity measurements were taken at 2.5', 5', and 10' depths by the "Wenner Four Pin" method, using an Associate Research Vibroground Model 263-A.

C. "As Found" pipe-to-soil potential measurements were obtained at each contact point on the underground fuel tanks and fuel lines. Measurements were obtained with a Miller Multi-Combination Meter, Model M-3-M. The term "as found" pipe-to-soil potentials refer to a measurement commonly used to determine the potential level on an underground metallic structure with any cathodic protection system operating as they have been in the past. The location of the readings are shown on the drawings provided in each section of the report.

D. Current tests and continuity tests were conducted to determine the current requirements, current attentuation and electrical continuity of the piping system. An investigation of stray current interference on the fueling system caused by any DC source, either on the facility or adjacent to it was also made.

E. Existing cathodic protection systems were checked and examined including the following work:

   1. <u>Sacrificial Anode Cathodic Protection Systems</u>:

      a. Each test box was located and painted by PCR engineers.

      b. Anode open circuit potentials were obtained at each test box to determine the material specifications of the anodes.

      c. Test leads in each test box were checked and tested to ensure their proper function.

d. Current output of each anode bed was measured at each test box to determine the condition of the anode.

e. Pipe-to-soil potentials were obtained on the test lead at each test box before and after the anode header cable was connected to the test lead.

2. Impressed Current Cathodic Protection Systems:

a. Rectifiers were examined and checked. The DC output of each rectifier was checked with a Miller Multi-Combination Meter, Model M-3-M. The tap settings and DC outputs of the rectifiers were recorded during this survey.

b. The anode header cable and the negative cable were traced with a stray current detector and a pipe line locator.

F. Spot visual inspections of the fuel distribution system and discussions with the Base personnel were made to determine from memory and records, the number and type of leaks experienced in the system.

G. Leak history of the fuel lines and fuel tanks was discussed with Mr. John Kimi, Mr. Edwin Katada, Mr. Albert Wong of Base Fuel Department, Mr. Bill Brown and Mr. Art Lundberger of the Public Works Department of the Naval Supply Center.

H. A review of the base personnel field tests, recordkeeping, test procedures, reporting periods and equipment available to test cathodic protection systems was made.

I. A review of adherence by base personnel and others to the

requirements contained in the Code of Federal Regulations, Title 49, DOT, Part 195 was made.

J. A report was prepared containing the field data, evaluation of field data, and the results of findings and recommendations.

K. A field data drawing was prepared for each section showing fuel tanks, fuel piping, existing known cathodic protection systems and identified test point locations.

L. A preliminary engineering cost estimate of the materials and installation costs for a recommended corrosion mitigation system was made for each section.

SECTION II

TEST METHODS AND DISCUSSIONS

SECTION II - TEST METHODS AND DISCUSSION

Corrosion Mechanism

The two basic mechanisms which result in corrosion of underground metal surfaces are electrolytic or stray current corrosion and galvanic corrosion. Both mechanisms involve an electrochemical reaction which converts metal into metallic salts and oxides. Stray currents, which are generated by outside sources such as arc welders, DC electric railroads, bell and signal systems and neighboring cathodic protection systems, are frequently very difficult to eliminate. Galvanic corrosion is the result of current flow caused by potential differences along the surface of a metallic structure that is submerged in an electrolyte such as soil or water. The action of a galvanic cell can be illustrated with a dry cell battery.

A large potential difference between the zinc container and the graphite rod, as evidenced by their relative positions on the galvanic series, results in current flow from zinc to graphite when the circuit is closed. Oxidation, or corrosion, may be defined as a reaction in which electrons are released by an element. In this galvanic cell the zinc is being oxidized. The chemical term for the electrode at which oxidation occurs is the anode; thus, zinc is the anode in this dry cell battery. The graphite rode is called the cathode or electrode where reduction (opposite of corrosion) occurs. The graphite may be considered "cathodically protected" from corrosion.

In order for current to flow in a galvanic cell, the anode

and cathode must be electrically connected, and both must be in contact with a common electrolyte. In the dry cell the "paste" or electrolyte in the zinc contaniner is particulary suited to allow a relatively large current flow and is very corrosive to zinc. The amount of current which can flow for a giver voltage depends on the conductivity of the electrolyte or its resisitivity, a reciprocal of conductivity. A more detailed explanation of resistivity is given in the section entitled "Soil Resistivity".

"Local action" corrosion results from micro-potential differences along the surface of a metal and appears to be a direct attack of the electrolyte. Over a long period of time, the zinc container of a dry cell battery deteriorated by itself. Currents which are generated at small anodic areas pass through the electrolyte and return to the metal surface at areas which become cathodic. These small galvanic cells are constantly changing location because of the effect of corrosion products on potential gradients of the metal surface.

Concentrated corrosion may be expected on the surface of a metallic structure which is in an environment of nonuniform composition. An uncoated metallic structure traversing soil of varying resistivity will develop anodic areas at locations where soil resistivity is low and cathodic areas where soil resistivity is high. At the anodic areas, potentials will be more negative than at the cathodic areas. Concentrated corrosion can be expected on a coated underground metallic structure at locations where the coating is damaged. At coating defects, the electrical resistance between the metallic structure and the electrolyte is much less

than at well coated sections, resulting in extreme variations of environment.

Bi-metallic corrosion, as illustrated by the dry cell battery, is the result of coupling different metals which are in contact with a common electrolyte such as water or soil. The following is an abbreviated list of common metals according to their relative tendency to corrode. This is normally referred to as the galvanic series.

Magnesium	Corroding (anode)
Zinc	
Galvanized Steel	
Aluminum	
Steel	
Cast Iron	
Lead	
Copper	
Graphite	Protected (cathode)

NOTE: When two metals on this list are coupled in an electrolyte, the higher one is the anode and the other is the cathode.

The corrosion activity of a zinc and graphite couple has already been discussed. Magnesium is frequently coupled with iron and steel purely as a sacrificial metal, so that the steel will not corrode. The most frequently encountered bi-metallic couple in piping systems is the copper-iron couple, in which iron corrodes and copper is protected.

Another condition similar to bi-metallic corrosion occurs when new and old underground structures of the same metal are connected.

New metallic structures are generally anodic with respect to old metallic structures and may corrode rapidly.

Soil Resistivity

When testing soil for its relative corrosiveness, measurements of soil resistivity are an invaluable aid to the corrosion engineer. Soil resistivity, which can be considered inversely proportional to soil corrosivity, is a measure of the resistance to the flow of electric current through the soil.

The soil resistivity measurements were obtained by the Wenner "four pin" method using an Associated Research Vibroground, Model 263A, as shown on Drawing No. 5001.

The Wenner "four pin" method consists of measuring the voltage drop across a given cross section of soil for a specific magnitude of current which is conducted through the soil. The average resistivity of the soil between the ground surface and depth "D" can be determined from the following formula, if the voltage across the inner pins is known for a given current impressed on the outer pins.

$$R = \frac{191.5\ DE}{I}$$

where:

R - Soil resistivity, ohms per cubic centimeter

D = Distance between electrodes, feet

E = Voltage drop between inner electrodes, volts

I = Current between outer electrodes, amperes

The ratio of E/I, which is obtained by introducing a resistance in the meter circuit exactly equal to that of the soil, is read directly from the Vibroground dial.

Soil resistivity is also useful in determining the type of cathodic protection which can be used at a specific site. In soils of low resistivity, galvanic anodes can often be used, but in soils of high resistivity, impressed current cathodic protection is generally desirable. Whether galvanic anodes or an impressed current cathodic protection system is utilized, the soil resistivity is necessary to estimate the current output of the anodes. If a rectifier system is selected, soil resistivity is one of the factors necessary for determining the location and number of anodes required, and the output capacity of the power source.

Pipe-to-Soil Potential

The term pipe-to-soil potential refers to a measurement commonly used to determine the degree of corrosion activity on an underground metallic structure. Pipe-to-soil potential is basically a measure of the emf or voltage of an underground metallic structure with respect to a reference electrode, such as the copper-copper sulfate half-cell. The soil serves as an electrolyte to provide a potential reference.

Pipe-to-soil potential measurements were taken with a Miller Multi-Combination Meter, Model M-3-M, as shown on Drawing No. 5000.

During measurements, the reference electrode is placed at a location near the structure being investigated so that a given section of the structure is in the "field" of the electrode. The potential is measured on a potentiometer when the circuit is completed by connecting the reference cell to the structure within the "field" of the electrode.

When a measurement is taken with the copper-copper sulfate half-cell, a potential of approximately -550 millivolts is the normally accepted noncorroding potential of an uncoated steel pipe. Potentials which are more negative than -550 millivolts are indicative of corrosion activity. If potentials taken at various locations along an uncoated underground structure are not uniform, and there are a number of readings less negative than -550 millivolts included with some readings that are more negative, "concentrated" corrosion will be active at the more negative locations.

Effects of bi-metallic corrosion on a structure-to-soil potential are somewhat different than those observed when "local action" or "concentrated" activity are prevalent. The potential measured when a ferrous structure is electrically connected to a more noble metal, or a metal of lower potential on the electromotive series, will be less negative than the -550 millivolt potential of noncorroding steel. Although the potential of the structure will become more positive as a result of the couple, corrosion will increase.

It is often useful to measure the structure-to-soil potential with the half-cell placed at some distance away from the structure as well as with the cell over the structure. This testing method provides a means of determining whether the particular section of structure is anodic or cathodic with respect to the remainder of the structure.

Stray Current Tests

During the operation of DC equipment (electrical railroads,

arc welders, neighboring cathodic protection systems, bell and signal systems, and laboratory equipment), "stray" or uncontrolled currents are often introduced into the ground. These currents can flow to an underground metallic structure, which is frequently of lower resistance than the soil. The current then flows to a point closer to the current source and leaves the structure. The location at which current leaves a metallic structure is the site of corrosion.

Because most stray currents are intermittent in nature, they can usually be detected during the measurement of pipe-to-soil potentials. Fluctuations in potential while a reading is being taken is nominal evidence of stray currents.

Current Requirement Tests

During a corrosion survey, it is possible, by proper evaluations of a variety of specialized tests, to design a system of electrical equipment which will substantially increase the service life of underground metallic facilities. Such a system causes current to flow from anodes to the subject structures making them cathodic, thus, the term cathodic protection.

In order to design a cathodic protection system for an underground piping network, it is necessary to install a temporary cathodic protection system which will simulate the operation of an actual system. There are two basic types of cathodic protection systems, one in which anodes are self energized by a DC power source and the other in which the anodes are self energized and are connected directly to the structure being protected. The gal-

vanic, or self energized anodes, are made of a material such as magnesium or zinc which is anodic to the structure being protected. These anodes have limited application and cannot be used where a large amount of current is necessary or where soil resistivity is in the higher ranges. Rectifier powered systems can be designed to deliver a greater magnitude of current for protecting metallic structures.

When a cathodic protection system is in operation, current flows from the anodes to the structure which is to be protected. The degree of cathodic protection can be determined by measuring the change in potential of the protected structure by means of a reference cell and potentiometer.

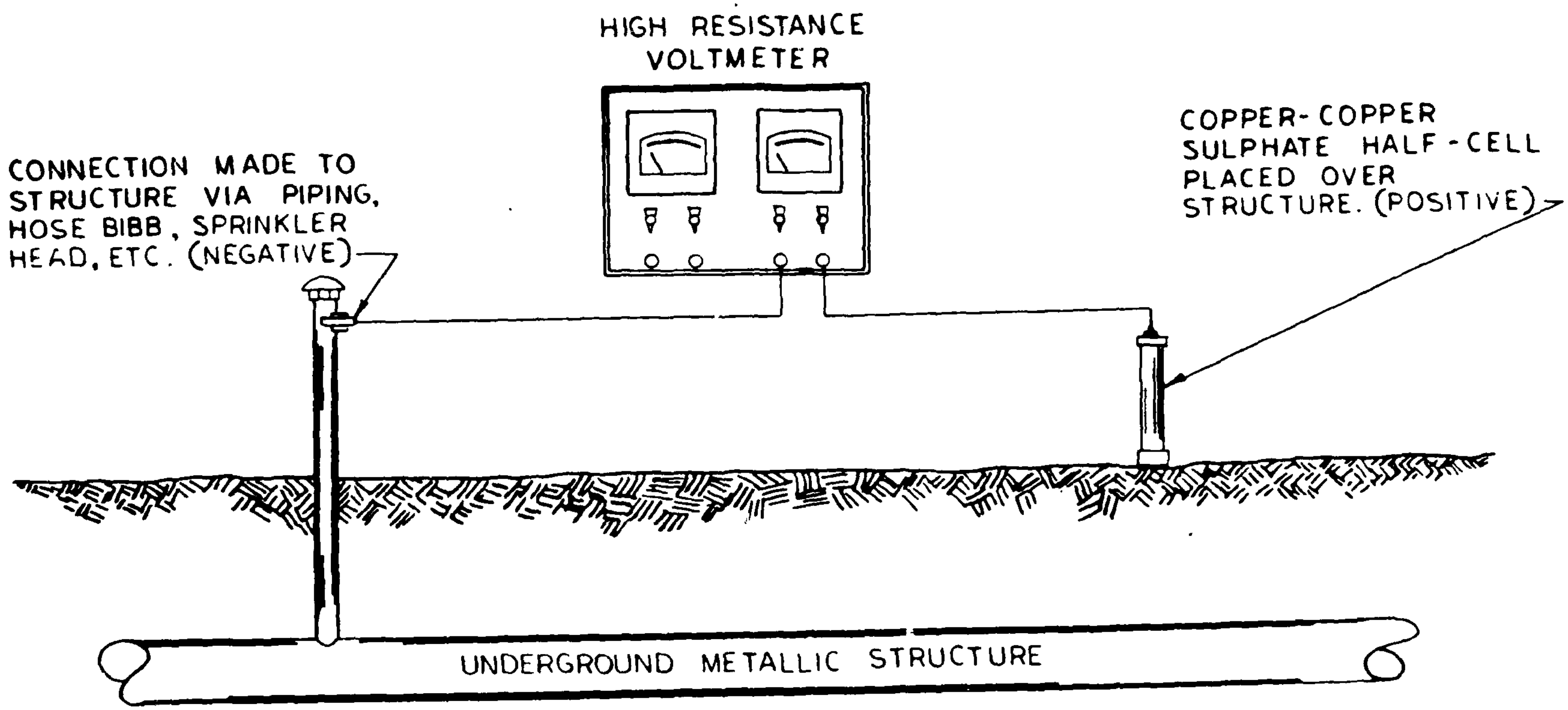
Several criteria for cathodic protection are in use at the present time, one of which requires a -850 millivolt resulting potential on iron and steel structures. Another criterion for protection is a minimum of 300 millivolts change of potential in the more negative direction. A final criteria for protection is that polorization is achieved.

Electrical Continuity Tests

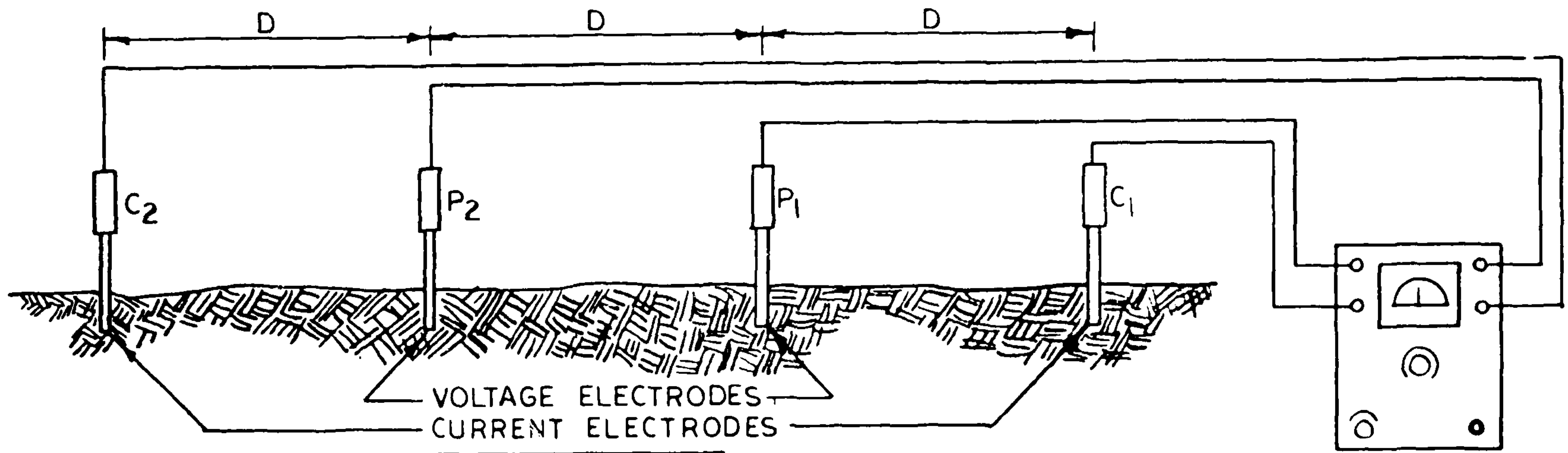
Current requirement tests are used in determining electrical continuity between the location where the negative terminal of the rectifier was connect and a location where a structure-to-soil potential is measured.

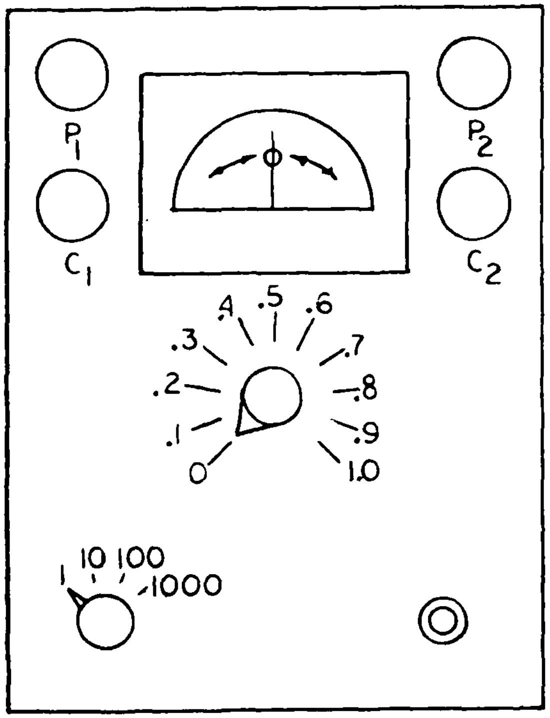
When the structure-to-soil potential is more negative after the application of cathodic protection, there is usually electrical continuity between the location where the measurement was taken

and the location where the cathode connection was made. If, on the other hand, the structure-to-soil potential is less negative as a result of the application of cathodic protection, there exists an electrical discontinuity.



PACIFIC CORROSION RESEARCH **CONSULTING CORROSION ENGINEERS**	
MEASUREMENT OF STRUCTURE-TO-SOIL POTENTIAL	
DRAWN: PCT	**DATE:** 7-25-62
APPROVED: ELJ	**NUMBER:** 5000





SOIL RESISTIVITY METER

FORMULA FOR CALCULATING SOIL RESISTIVITY

$$R = \frac{191.5\,DE}{I}$$

P = SOIL RESISTIVITY OHM-CENTIMETERS
D = DISTANCE BETWEEN ELECTRODES IN FEET
E = VOLTAGE CHANGE, MILLIVOLTS
I = CURRENT MILLIAMPERES

PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS

MEASUREMENTS
OF
SOIL RESISTIVITY

DRAWN: P.T.	**DATE:** 7-25-62
APPROVED: FCH	**NUMBER:** 5001

SECTION III

FIELD WORK AND EVALUATION OF FIELD DATA

SECTION III

SECTION III - FIELD WORK AND EVALUATION OF FIELD DATA

General:

Available drawings were provided by Mr. Fred Nakamura, Project Design Engineer and Mr. Edwin Katada, Fuel Department Engineer, NSC, during this survey.

The fuel tanks and fuel piping to be considered for cathodic protection under this contract are as follows:

Section A-1: POL lines outside Pearl Harbor Complex, including one 16" avgas line form Pearl City Pumphouse to Red Hill Fuel Storage Area.

Section A-2: POL lines outside Pear Harbor Complex, including one 18" avgas line from Victor Docks to Pearl City Tank Farm.

Section A-3: POL lines outside Pearl Harbor Complex, including two 10" avgas lines serving Hickam AFB from Victor Docks to the crossing at Middle Loch.

Section A-4: POL lines outside Pearl Harbor Complex, including one 8" avgas line serving NAS Barbers Point from Pearl City Tank Farm.

Section A-5: POL lines outside Pearl Harbor Complex, including the interconnecting lines from the pumphouse on the Pearl City Peninsula.

Section B-1: POL lines inside the Pearl Harbor Complex, including the lines from VC-1 to Hotel Pier.

Section B-2: POL lines inside the Pearl Harbor Complex, including lines from VC-1 to Kilo and Hotel Pier.

Section B-3: POL lines inside the Pearl Harbor Complex, including the lines from VC-4 to Sierra Piers.

Section B-4: POL lines inside the Pearl Harbor Complex including the lines from VC-1 to Sierra Piers, Mike Docks and the Upper Tank Farm.

Section B-5: POL lines inside the Pearl Harbor Complex including the lines from VC-1 to the Upper Tank Farm.

Section B-6: POL lines inside the Pearl Harbor Complex including the lines from VC-1 to the Upper Tank Farm and the Middle Tank Farm.

Section B-7: POL lines inside the Pearl Harbor Complex including the lines from the Middle Tank Farm to the Mike Docks.

Section B-8: POL lines inside the Pearl Harbor Complex from Bldg. 88 to Mike Docks.

Section B-9: POL line inside the Pearl Harbor Comples including the 12" DFM from VC-20 to a point northwest of Bldg. 599 on Baker Docks.

Section B-10: POL lines inside the Pearl Harbor Complex from Pumphouse 76, Lower Tank Farm, to Bldg. 177 and 149 in the restricted Naval Shipyard area.

Section C-1: This section includes one 25,000 bbl, two 80,000 bbl and two 150,000 bbl tanks in the Pearl City Tank Farm.

Section C-2: This section includes six 150,000 bbl tanks, eight underground diesel storage tanks at Bldg. 60, four 10,000 bbl underground surge tanks, two ballast

tanks, two diesel tanks, one hot settling tank and one diesel flotation unit.

<u>Section C-3</u>: This section includes four 50,000 bbl tanks and one 80,000 bbl tank at the Middle Tank Farm.

<u>Section C-4</u>: This section includes four 50,000 bbl tanks at the Lower Tank Farm.

<u>Section C-5</u>: This section includes one outdoor ballast tank and one water storage tank at the stilling basin and associated piping.

<u>Section D-1</u>: Fuel Piers - We were instructed to omit this from this contract.

<u>Section D-2</u>: Truck Loading Facilities - These are included in the appropriate pipeline section.

<u>Section E-1</u>: Existing impressed current type of cathodic protection systems.

<u>Section E-2</u>: Existing sacrificial anode type of cathodic protection systems.

<u>Section F</u>: C.F.R. 49, Part 195 - Status of Compliance and Recommendations for compliance.

SECTION IV

FIELD TESTS OF CATHODIC PROTECTION SYSTEMS BY BASE FUEL PERSONNEL

SECTION IV - FIELD TESTS OF CATHODIC PROTECTION SYSTEMS BY BASE FUEL PERSONNEL:

A. Test Procedures: These are performed by Mr. Albert Wong, Electronics Technician.

1. Rectifiers: Each rectifier is inspected and recorded monthly on "Cathodic Protection Inspection Report Sheet".

2. Pipe-to-Soil Potentials: Potentials are obtained twice a year at various valve chambers and test stations and recorded on "Cathodic Protection Inspection Report Sheets".

3. Instrumentation Used: A Simpson voltmeter and a copper-copper sulphate reference electrode half cell, manufactured by M. C. MILLER, INC. are used.

B. Recordkeeping: After completion of field tests, a complete copy of all data is provided to Mr. Jim Gammon, Superintendent, Fuel Department and one copy is sent to Pacific Division for evaluation. The original "Cathodic Protection Inspection Report", sheets are filed in a log book by Mr. Albert Wong.

C. Recommendations:

It is recommended that the following minimum testing, recording and maintenance procedures be instituted for the existing and proposed systems:

1. The rectifiers should be inspected and the D.C. outputs recorded monthly.
2. The rectifiers should be cleaned quarterly.
3. The existing test points (pipe-to-soil potential locations) that were designated by the base personnel and additional necessary test points that were used during this survey have been identified and are shown on the field data drawings under each section. It is recommended that potentials be obtained at all identified locations quarterly. While obtaining the potentials at valve chambers, it is recommended, that the half cell be placed over the pipeline at least 3' away from the valve chamber.
4. Sacrificial anode bed open circuit potential and anode bed current flow measurements should be obtained at each test box and the results recorded semi-annually.
5. Base personnel should keep and maintain sufficient drawings showing all cathodic protection systems of the fueling system. Any repairs and/or damages caused by base personnel or others, should be reported to the Fuel Department immediately and recorded by them.
6. All test leads, shunts, split bolts, anode leads and wire connections in eact test box should be checked and the results and repairs recorded semi-annually.
7. All insulators should be checked and the results and repairs recorded quarterly.

8. It should be mentioned that coatings may become disbonded in the area where pipe-to-soil potentials with respect to a copper-copper sulphate reference electrode are excessive. This effect is not considered damaging to ferrous metals, however, increased surface area of the metallic structure will become exposed. This will increase the demand for cathodic protection current. Therefore, we recommend to maintain a pipe-to-soil potential of not more than 3 volts for protection of X-Tru-Coated ferrous metallic structures and not more than 2.5 volts for coal tar coated ferrous metallic structures.

9. While obtaining the tank and/or pipe-to-soil potentials in the blacktop and/or in the concrete areas, the following precautions should be exercised:

   a. Drill a 3/4" hole through the blacktop and/or concrete slab over the pipeline and/or 24" away from the tank.
   b. Fill the hole with sand and/or native soil.
   c. Fill the hole with water until the backfill in the hole is totally saturated.
   d. Place the copper-copper sulphate reference electrode half cell over the hole.
   e. Use a Miller Multi-Combination Meter, Model M-3-M, to obtain the potential readings by means of potentiometer.
   f. Tank-to-soil potentials should be obtained at four sides of an above ground metallic tank. An additional potential should be obtained in the center and over an underground metallic tank.

10. The following instrumentation and equipment is required for base fuel personnel to perform the field testing as recommended. It is shown on the following two pages.

INSTRUMENTATION & TEST EQUIPMENT REQUIRED

PEARL HARBOR, HAWAII

Item	Description	Supplier Address	Delivery	Quantity	Est. Cost
1.	M-3-Al MC Miller Multi-Combination Meter	M.C. Miller Co. 288 E. Saddle River Rd. Upper Saddle River, N.J. 07458	10 days + Frt. time	2	2x$720.=$1440.00 Frt.= 50.00 $1490.00
2.	Model RES Copper-Copper Sulphate *Half Cells*, M.C. Miller	M.C. Miller Co. 288 E. Saddle River Rd. Upper Saddle River, N.J. 07458	10 days + Frt. time	6 40 oz. $Cu\text{-}So_4$	6x$ 18.=$ 108.00 16.= 16.00 Frt.= 20.00 $ 144.00
3.	Vibroground, Model 263A Associated Research, Inc.	Associated Research, Inc. 3758 W. Belmont Ave. Chicago, Ill. 60618	6 weeks + Frt. time	2	2x$450.=$ 900.00 Frt.= 41.00 $ 941.00
4.	Resistivity Pin Set	Base Personnel Fabricate		2	
5.	Pipeline Locator Model P-460 CS Model 810 C with Metroclamp	Metrotec Corp. 670 National Avenue Mountain View, Ca. 94043	6 weeks + Frt. time 12 weeks + Frt. time	1 1	$ 500.00 1500.00 Frt. 20.00 $2020.00
6.	Test Rectifier PACIFIC CORROSION RESEARCH	Pacific Corrosion Research 5481 B Commercial Drive Huntington Beach, Ca. 92649	6 weeks + Frt. time	1	$650.=$ 650.00 Frt.= 50.00 $ 700.00
7.	Steel Rods ½" x 24" for Test Anodes	Base Personnel Fabricate		40	
8.	#8 AWG TW Insulated Stranded	Base Personnel Provide		two-500 ' Boxes	
9.	#18 AWG Machine Tool Wire & Reels	M.C. Miller Co. 288 E. Saddle River Rd. Upper Saddle River, N.J. 07458	10 days + Frt. time	5 reels w/500' ea.	$ 70.=$ 350.00 Frt.= 40.00 $ 390.00

Item	Description	Supplier Address	Delivery	Quantity	Est. Cost
10.	Alumino-Thermic Welding Kit, Erico Products	Erico Products 2070 E. 61st Place Cleveland, Ohio	10 days + Frt. time	1 box/100 Charges Tool Kit 2 molds @ $20. CAMB 7101 CASR 1327 Frt.	$ 50.00 35.00 40.00 25.00 15.00 20.00 $ 185.00
11.	2500 to 3000 Watt Portable Generator, 110 V-1Ø	Base Personnel has available		1	
12.	Valve Box Locator	Metrotech Corp. 670 National Avenue Mountain View, Ca. 94043	6 weeks + Frt. time	1	$ 250.00 16.00 $ 266.00
13.	Misc. Clips, Test Leads Tools, etc.	Base Personnel Fabricate as required			

Total (not *including material* by Base personnel) $6,136.00

SECTION V

SOIL SAMPLES

SECTION V

SECTION V - SOIL SAMPLES

A total of twenty-three soil samples were obtained from a depth of 18" to 3'. At the following locations, pH readings were obtained on these samples. An average soil resistivity measurement at a 10' depth was obtained at each sample location.

SOIL SAMPLE NO.	SECTION	LOCATION	pH	AVERAGE SOIL RESISTIVITIES (ohm-cms)
1.	A-1	Exist. Test Point #50	7.7	2200
		Halawa Heights		
2.	A-1	Aiea Kai Way	7.6	400
3.	A-2	SE of Bldg. 75	7.5	480
4.	A-3	N of Victor Docks	8.1	300
5.	A-4	Near VC-4	8.1	
		Pearl City Tank Farm		2400
6.	A-4	Near Standard Oil Co. T.	7.5	
7.	A-5	N of Tank S88	7.4	280
		Pearl City Tank Farm		
8.	B-1	Near T.B. #2, S. of VC-2 NSC	7.9	10000
9.	B-2	E. of Bldg. 475, NSC	7.2	1540
10.	B-3	NE of Bldg. 460, NSC	7.7	1200
11.	B-4	By VC-31, NSC	7.7	400
12.	B-5	SE of Tank 48, Upper Tank Farm	7.7	1080
13.	B-6	SE of Bldg. 186, by VC-23	7.8	3600

14.	B-7	SW of Tank 36, Middle Tank Farm	8.2	980
15.	B-8	N. of Bldg. 88, W. of POL lines	8.1	3600
16.	B-9	NE of Bldg. 68, Baker Docks	8.3	1080
17.	B-10	S. of Bldg. 93, NSY	8.2	6000
18.	B-10	N. of Tank 10	8.8	10000
19.	C-1	Near line into Pearl City Tank Farm	7.9	400
20.	C-2	W. of Tank 37, Middle Tank Farm	8.3	2800
21.	C-3	Between Tanks 34 & 35, Middle Tank Farm	8.1	4000
22.	C-4	Between Tanks 11 & 13, Lower Tank Farm	8.0	5800
23.	C-5	N. of Tank 355 by Adit #6	8.4	250

A pH of 7 is considered to be a neutral solution, while a pH of 0 represents a very acidic media and a pH of 14 or above is very alkaline.

An acid environment is generally more corrosive on underground metallic structures than an alkaline environment. Alkaline conditions of soil can be detrimental to aluminum and lead piping.

It is recommended that no aluminum pipe be used in the future for the POL piping systems in the Bulk Fuel Terminals at the Naval Supply Center, Pearl Harbor, Hawaii, without careful consideration to its unique properties, including strict limitations on cathodic protection potentials.

SECTION VI

RECAP OF ENGINEERING COST ESTIMATE

SECTION VI

SECTION VI - RECAP OF ENGINEERING COST ESTIMATE

A preliminary cost estimate for the material and installation of the recommended cathodic protection systems has been made, as shown on the cost estimate sheet, under each section. The following is a recap of the engineering cost estimates.

SECTION	MATERIALS	INSTALLATION	SUBTOTAL
A-1	$ 59,336.55	$ 31,252.65	$ 90,589.20
A-2	22,527.05	11,984.05	34,511.10
A-3	30,162.92	42,535.35	72,698.27
A-4	56,176.90	38,715.95	94,892.85
A-5	44,118.10	19,554.60	63,672.70
B-1	54,285.40	54,362.10	108,647.50
B-2	21,596.90	13,406.25	35,003.15
B-3	6,215.35	5,697.12	11,912.47
B-4	3,567.56	1,800.80	5,368.36
B-5	25,350.32	58,077.30	83,427.62
B-6	2,792.56	4,045.47	6,838.03
B-7	10,016.82	8,426.60	18,443.42
B-8	2,160.60	2,069.47	4,230.07
B-9	739.05	815.10	1,554.15
B-10	71,389.17	123,838.72	195,227.89
C-1	WILL BE PROTECTED BY THE RECOMMENDED C.P. SYSTEM FOR SEC. A-2 & A-5		
C-2	55,437.98	37,523.20	92,961.18
C-3	10,974.27	9,617.40	20,591.67
C-4	22,747.27	31,214.95	53,962.22
C-5	28,814.82	17,080.05	45,894.87
TOTAL	$528,409.59	$512,017.13	$1,040,426.72

Based on the field data obtained from this survey, a cathodic protection system consisting of both impressed current and sacrificial anode types would be most effective and economical. An impressed current type of cathodic protection system will be most effective for the major portions of this project. The high current demand makes it economically unfeasible to consider a sacrificial anode type of cathodic protection system. The cost of a sacrificial anode system will be approximately six times the cost of an impressed current system, with similar current outputs and a service life of 20 years.

The cost estimate of the rectifiers are based on their D.C. capacities. A cost of $1,950.00 and $2,700.00 was used for a 30 Amps and a 60 Amps D.C. respectively, in this estimation.

SECTION A-1

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX,

INCLUDING ONE 16" JP-5 LINE FROM

PEARL CITY PUMPHOUSE TO RED HILL STORAGE AREA

SECTION A-1

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX, INCLUDING ONE 16" JP-5 LINE FROM PEARL CITY PUMPHOUSE TO RED HILL STORAGE AREA

SECTION A-1

SUMMARY

1. Conclusions:

Based on the field data obtained, the following results were observed:

A. The soil resistivity measurements obtained in the field show a non-uniform environment. Where pipelines traverse areas of varying resistivity, corrosion will take place in the area of the lower resistivity. We would expect corrosion attack to occur on the underground metallic lines, particularly in the areas of the low soil resistivity.

B. The 16" JP-5 lines of Section A-1 are not at a protective potential level.

C. The 16" JP-5 lines of Section A-1 were found to be electrically continuous with the POL lines of Sections A-2, A-4, A-5 and the water piping system of the fresh water storage tank (Section C-5).

D. The underground 16" JP-5 and the 8" sludge lines are isolated from the above ground lines in the concrete tunnel at Adit #6. The 8" sludge line is also isolated from Sludge Tank #355.

E. Interference was found on the Navy owned 42" cast iron water, three Standard Oil lines and the 8" Honolulu Gas Company lines resulting from the existing Navy anode bed of Rectifier #13.

F. Interference was found on the Navy owned 42" cast iron water main and the 16" JP-5 lines in the area west of Aiea Bay resulting from the anode bed of a Standard Oil Company rectifier which is located northwest of Aiea Stream.

G. All the casing vent pipes for the 16" JP-5 lines were found to be electrically discontinuous with the 16" JP-5 except the vent pipes at the road crossing on the west side of the Aloha Stadium.

H. During this survey, existing Rectifiers #12 and #13 were found to be inoperative. A break in the anode header cable of Rectifier #12 was found near the tidal level and a failure in the A.C. power supply to Rectifier #13 was found west of Adit #3, between the first pull box and the second pull box. This A.C. power failure was repaired by Mr. Edwin Katada and Mr. Albert Wong in November of 1981.

I. Approximately 134,000 sq. ft. of coated steel POL lines are to be considered for cathodic protection in Section A-1. Approximately 50 amperes D.C. will be required to provide protection.

2. Recommendations:

A. To eliminate interference on the Honolulu Gas Company owned gas lines and the Standard Oil Company owned fuel lines, the following recommendations are made:

1. Install a distributive type of cathodic protection system by increasing the number of anode beds and associated equipment.

2. Install low voltage rectifiers by increasing the number of anodes and thereby reducing the circuit resistance.

3. Install sacrificial anodes in the area where the 16" JP-4 lines and the other foreign lines are congested.

4. Install resistance bond stations between the 16" JP-5 line and and the foreign lines at each future anode bed location (impressed current system). Joint testing should be undertaken to eliminate any interference.

B. The existing anode bed of Rectifiers #12 and #13 should be replaced with ten (10) 4½"x60" high silicon iron anodes and ten (10) 4"x80" graphite anodes respectively. The existing Rectifiers #12 and #13 should be replaced with new oil cooled rectifiers having a low voltage D.C. capacity.

C. The current tests conducted indicated that an additional impressed current anode bed, consisting of ten (10) 4½"x60" high silicon iron

anodes and four additional sacrificial anode beds, consisting of four test boxes, fifteen (15) 50 lb. prepackaged magnesium anodes and five (5) 4"x4"x36" - 150 lb. zinc anodes, should be installed to provide additional protection for the underground 16" JP-5 lines in the areas where other foreign lines are congested with the 16" JP-5 line.

D. An insulating flange set and a resistance bond station should be installed on the 16" JP-5 line in the existing valve chamber, east of S777.

E. It is recommended that the coating of the above ground JP-5 lines be inspected at least twice a year and repaired as necessary.

F. A test box and two 50 lb. prepackaged magnesium anodes should be installed at each of the following casings:

1. Aiea Kai Way Crossing.
2. Highway 78 Crossing.
3. Kahuapani Street Crossing.
4. Ulune Street Crossing.
5. Halawa Crusher Road Crossing.
6. Halawa Crusher Road Crossing (16" JP-5 line to VC-40).

POL LINES OUTSIDE PEARL HARBOR COMPLEX, INCLUDING ONE 16" JP-5 LINE FROM PEARL CITY PUMPHOUSE TO RED HILL STORAGE AREA

1. Description.

A. Lines to be protected:

(1) From Pearl City Pumphouse to Red Hill

a. 16" JP-5 line - Coated Steel

(2) From Adit #6 to Ballast Tank #355

a. 8" Sludge Line - Coated Steel

B. Existing Cathodic Protection System:

This section of POL lines were originally designed to be protected by an impressed current cathodic protection system consisting of the following rectifiers and their associated anode beds:

(1) Existing Rectifier #12

a. Rectifier Location: This air cooled rectifier is located in Pearl Harbor Park.

b. Rectifier Unit: MFG. - Goodall Mfg. Co.
Serial No. - CAWSC 28-46
D.C. Capacity - 28 Volt 46 Amp
Operating at - Tap setting 2-3
D.C. Output - 10 Volt 0 Amp
Date Recorded - October 10, 1981

c. Anode Bed Location: This anode bed consists of an unknown number of anodes placed on the sea floor south of existing Rectifier #12.

The anode bed header cable was traced with a stray current detector and a pipeline locator. A break in the anode header cable was found in the tidal zone south of Rectifier #12.

(2) Existing Rectifier #13

a. Rectifier Location: This air cooled rectifier is located east of VC-40 and north of H3 Freeway.

b. Rectifier Unit: MFG. - Goodall Mfg. Co.
Serial No. - Unknown
D.C. Capacity - 28 Volt 48 Amp
Operating at - Tap setting C-5
D.C. Output - 10 Volt 9.5 Amp
Date Recorded - October 11, 1981

c. Anode Bed Location: This anode bed consists of an unknown number of graphite anodes installed on the south side of H3 Freeway.

The negative and positive header cables were traced with a stray current detector and pipeline locator. No breaks were found in the D.C. header cable, however, an open circuit was found in the A.C. supply underground between the first pull box and the second pull box in the area adjacent to Adit #3. Temporary A.C. supply to this rectifier was made by Mr. Edwin Katada and Mr. Albert Wong during this survey. This temporary A.C. supply will be used until permanent repairs are made.

2. Field Work and Evaluation of Data.

A. Soil Resistivity Measurements: A total of forty-two sets of measurements were obtained at representative locations along the 16" J)-5 line as shown in Table No. I-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm/cm^3)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	38	Severe
Medium	2,000 - 10,000	59	Moderate
High	10,000 - 30,000	12	Slight unless other factors are pronounced
Very High	Above 30,000	3	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on underground metallic structures. Thirty-eight percent of the measurements obtained were in the severe category and fifty-nine percent were in the moderate or medium category.

B. "As Found" Pipe-to-Soil Potentials: "As Found" pipe-to-soil potentials were obtained at each valve chamber and at each test station after a temporary A.C. power supply to Rectifier #13 was made and the rectifier had been energized for three days. The results of these measurements indi-

cate that approximately 95% of the 16" JP-5 line is not at a protective potential level. Only a small portion of the 16" JP-5 lines south of Haw'n Electric Company. Waiau Power Plant was found to be under cathodic protection. The Standard Oil Company owns one 4" and two 8" lines which run along and parallel to the Navy owned 16" JP-5 line from a point south of Hale Mohalu Hospital to the Navy Supply Center, are cathodically protected by Standard Oil Company. The HIRI owned fuel line in the area adjacent to the Navy Supply Center, is also cathodically protected by HIRI.

C. Current Tests: Four current tests were conducted on this section of POL lines. Pipe-to-soil potentials were obtained at representative locations on the Navy owned 16" JP-5 lines and the 42" water lines, Standard Oil Company owned fuel lines and the vent pipes for the 16" JP-5 casings.

(1) Current Test No. 1 - This current test was conducted with the existing Rectifier #13 turned "off" and "on". This rectifier was operating at a tap setting of C-5, 10 volts and 9.5 amperes D.C. during this test. The results of this current test are shown in Table No. I-C in the appendix of this section.

(2) Current Test No 2 - This current test was conducted in the area adjacent to an existing test station approximately 700' west of Adit #6. A test bed consisting of ten steel rods was installed 30' north of

the 16" JP-5 line on the north side of the existing station. The negative from a test rectifier was connected to the test lead at the existing test station. The results of this test are shown in Talbe No. I-D in the appendix of this section.

(3) Current Test No. 3 - This current test was conducted in the area south of existing Rectifier #12 in Pearl Harbor Park. Two sections of 4' channel iron were submerged in the seawater approximately 5' under the tide level with the anode header cable connected to the D.C. positive terminal of existing Rectifier #12. The current used for this test was 13 amperes D.C.. The results of this test are shown in Table No. I-E in the appendix of this section.

(4) Current Test No. 4 - This test was conducted in the area adjacent to Aiea Stream. An existing rectifier, which is owned by the Standard Oil Company and located under the Kamehameha Highway on the west side of the Aiea Stream, was used for this test. The test was conducted by interrupting its A.C. power supply "off" and "on". The results of this test may be found in Table No. I-F in the appendix of this section.

The data obtained from these current tests provided the following conclusions:

(a) The 16" JP-5 lines of Section A-1 are electrically continuous with Sections A-2, A-4, A-5 and C-1.

(b) The 42" cast iron water main, which runs parallel to

the 16" JP-5 line from the Navy Supply Center to Hale Mohalu Hospital area, was found to be electrically discontinuous with the 16" JP-5 line and the Standard Oil Company fuel lines.

(c) The Standard Oil Company fuel lines were found to be cathodically protected by Standard Oil Company.

(d) The 16" JP-5 line is electrically continuous with the fresh water tank piping system at Adit #3.

(e) The 8" Honolulu Gas Company X-Tru coated gas line was found to be cathodically protected by them. This gas line is not electrically continuous with 16" JP-5 line.

(f) An insulator on the 16" JP-5 line in the tunnel at Adit #6 was checked and found to be effective. The underground 8" sludge line was found to be electrically isolated from the aboveground line at Tank # 355 and again in the tunnel at Adit #6.

(g) Interference was found on the following lines:

(1) Interference was found on the Honolulu Gas Company owned 8" gal line from Kahuapani Street to Aiea Elementary School from the Navy existing anode bed (Rectifier #13).

(2) Interference was found on the Navy owned 16" JP-5 and the 42" water main caused by the Standard Oil Company rectifier and anode bed.

(h) The casing vent pipes for the 16" JP-5 line, at each road crossing, were checked. The following casing

vent pipes were found not to be electrically continuous with 16" JP-5 line.

(1) Aiea Kai W[illegible] Crossing.

(2) Highway 78 Crossing.

(3) Kahuapani Street Crossing.

(4) Ulune Street Crossing.

(5) Halawa Crusher Road Crossing.

(6) Halawa Crusher Road Crossing (to VC-40)

The casing vent pipe on the west side of Aloha Stadium is electrically continuous with the 16" JP-5 line.

(i) The results of current tests indicate that current demand for the underground 16" JP-5 line of Section A-1 will be moderate.

D. Inspection of POL Pipelines: The coating of the POL lines on each bridge crossing was inspected in August of 1981. The coating was found to have damaged and deteriorated portions in some areas due to fishing activities in these locations. The coating was inspected again in December of 1981 and it was found that the damaged coating areas had been repaired by Base fuel personnel.

E. Leak History: We were advised by Base fuel personnel that there were no known leaks in the POL lines of Section A-1 at the present time and none had occured in the past to their knowledge.

3. Conclusions.

Based on the field dat obtained, the following results were observed:

A. The results of the soil resistivity measurements indicate that 38% of the readings are in the severe corrosion category, 59% are in the moderate category and 15% are in the slight and non-corrosive category. The measurements obtained in the field show a non-uniform environment. Where pipelines traverse areas of varying resistivity, corrosion will take place in the area of the lower resistivity. We would expect corrosion attack to occur on the underground metallic lines, particularly in the areas of the low soil resistivity.

B. The 16" JP-5 lines of Section A-1 are not at a protective potential level.

C. The 16" JP-5 lines of Section A-1 were found to be electrically continuous with the POL lines of Sections A-2, A-4, A-5 and C-1.

D. The underground 16" JP-5 and the 8" sludge lines are isolated from the above ground lines in the concrete tunnel at Adit #6. The 8" sludge line is also isolated from Sludge Tank #355.

E. The 16" POL lines of Section A-1 is electrically continuous with the water piping system of the fresh water storage tank (Section C-5).

F. Interference was found on the Navy owned 42" cast iron water, the three Standard Oil lines and the 8" Honolulu Gas Company lines resulting from the existing Navy anode bed of Rectifier #13.

G. Interference was found on the Navy owned 42" cast iron water main and the 16" JP-5 lines in the area west of

Aiea Bay resulting from the anode bed of a Standard Oil Company rectifier which is located northwest of Aiea Stream.

H. All the casing vent pipes for the 16" JP-5 lines were found to be electrically discontinuous with the 16" JP-5 except the vent pipes at the road crossing on the west side of the Aloha Stadium

I. During this survey, existing Rectifiers #12 and #13 were found to be inoperative. A break in the anode header cable of Rectifier #12 was found near the tidal level and a failure in the A.C. power supply to Rectifier #13 was found west of Adit #3 between the first pull box and the second pull box.

J. The results of the current tests conducted indicated that the current demand for Section A-1 will be moderate. Approximately 134,000 sq. ft. of coated steel POL lines are to be considered for cathodic protection in Section A-1. Approximately 50 amperes D.C. will be required to provide protection.

4. <u>Recommendations</u>.

A. To eliminate interference on the Honolulu Gas Company owned gas lines and the Standard Oil Company owned fuel lines, the following recommendations are made:

1. Install a distributive type of cathodic protection system by increasing the number of anode beds and associated equipment.

2. Install low voltage rectifiers by increasing the number of anodes and thereby reducing the circuit resistance.

3. Install sacrificial anodes in the areas where the 16" JP-4 lines and the other foreign lines are congested.

4. Install resistance bond stations between the 16" JP-5 line and the foreign lines at each future anode bed location (impressed current system). Joint testing should be undertaken to eliminate any interference.

B. The existing anode bed of Rectifier #12 should be replaced with ten 4½"x60" high silicon iron anodes. These anodes should be installed on the south side of the 16" JP-5 line. Rectifier #12 should be replaced with a new oil cooled rectifier having a low voltage D.C. capacity.

C. The existing anode bed of Rectifier #13 should be replaced with ten 4"x80" graphite anodes. These anodes should b installed on the north side of the 16" JP-5 lines. Rectifier #13 should be replaced with a new oil cooled rectifier having a low voltage D.C. capacity. An anode watering system should be installed for this anode bed.

D. The current tests conducted indicated that an additional impressed current bed and four additional sacrificial anode beds should be installed to provide additional protection for the underground 16" JP-5 lines in the areas where other foreign lines are congested with the 16" JP-5 line.

1. Impressed Current Anode Bed - This anode bed should be installed in the area adjacent to the Sludge Tank #355 and will consist of ten 4½"x60" high silicon iron anodes and an anode watering system. This recommended anode bed will provide protection for the exterior tank

bottom of the sludge tank (Section C-5) and a portion of the 16" JP-5 lines from Adit #6 to Adit #3.

2. Sacrificial Anode Bed -

   a. The first anode bed should be installed on the east side of Lehua Avenue and west of the baseball field. It will consist of five 50 lb. prepackaged magnesium anodes, a test box and an anode watering system.

   b. A second anode bed should be installed at the existing test station southwest of Hale Mohalu Hospital. It will consist of five 50 lb. prepackaged magnesium anodes, a test box and an anode watering system.

   c. A third anode bed should be installed on the south side of the 16" JP-5 line at the existing test station. It will consist of five 4"x4"x36", 150 lb. zinc anodes and a test box.

   d. A fourth anode bed should be installed northwest of Halawa Heights Drive at the existing test station. It will consist of five 50 lb. prepackaged magnesium anodes, a test box and an anode watering system.

E. An insulating flange and a resistance bond station should be installed on the 16" JP-5 line in the existing valve chamber east of S777.

F. It is recommended that the coating of the above ground JP-5 lines be inspected at least twice a year and repaired as necessary.

G. A test box and two 50 lb. prepackaged magnesium anodes should be installed at each of the following casings:

1. Aiea Kai Way Crossing.
2. Highway 78 Crossing.
3. Kahuapani Street Crossing.
4. Ulune Street Crossing.
5. Halawa Crusher Road Crossing.
6. Halawa Crusher Road Crossing (16" JP-5 line to VC-40)

NOTE: The pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawings No. 6491 and 6492.

The recommended C.P. systems of Section A-1 are shown on PCR Drawings No. 6491-A and 6492-A.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION A-1

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
4½"x60" HI SILICON IRON ANODES	20	ea	720.00	14400.00	150.00	3000.00	870.00	17400.00
4"x80" GRAPHITE ANODES	10	ea	330.00	3300.00	150.00	1500.00	480.00	4800.00
OIL COOLED RECTIFIERS	3	ea	1950.00	5850.00	600.00	1800.00	2550.00	7650.00
50 LB. PREPACKAGES MAGNESIUM ANODES	27	ea	225.00	6075.00	150.00	4050.00	375.00	10125.00
4"x4"x36" - 150 LB. ZINC ANODES	5	ea	450.00	2250.00	150.00	750.00	600.00	3000.00
#2 HMP STRANDED COPPER CABLE	1400	ft	1.50	2100.00	0.15	210.00	1.65	2310.00
#8 HMP STRANDED COPPER CABLE	700	ft	0.75	525.00	0.15	105.00	0.90	630.00
COAL COKE BREEZE	10500	lb	0.30	3150.00	0.08	787.50	0.38	3937.50
1" PVC CLASS 200, PLASTIC PIPE	1500	ft	0.75	1125.00	0.15	225.00	0.90	1350.00
INSULATING FLANGE SET	1	ea	45.00	45.00	75.00	75.00	120.00	120.00
RESISTANCE BOND STATION	5	ea	150.00	750.00	150.00	750.00	300.00	1500.00
CONCRETE PAD	3	ea	150.00	450.00	300.00	900.00	450.00	1350.00
SPLIT BOLTS	80	ea	1.05	84.00	4.50	360.00	5.55	444.00
CONCRETE TEST BOXES/CAST IRON LIDS	10	ea	45.00	450.00	75.00	750.00	120.00	1200.00
HOSE CONNECTION ADAPTERS	13	ea	7.50	97.50	7.50	97.50	15.00	195.00
0.01 OHM SHUNTS	10	ea	7.50	75.00	7.50	75.00	15.00	150.00
COAL TAR ENAMEL (1 GALLON CAN)	3	ea	22.50	75.00	45.00	135.00	67.50	202.50

S/N 0105-LF-010-1335
★ G.P.O. 1979-689-016/4302

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982 | SHEET 2 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM CORROSION SURVEY, SECTION A-1

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
BUTYL TAPE	4	rl	37.50	150.00	45.00	180.00	82.50	330.00
RUBBER TAPE	12	rl	4.50	54.00	7.50	90.00	12.00	144.00
PLASTIC TAPE	12	rl	4.50	54.00	7.50	90.00	12.00	144.00
TERRA TAPE	1500	ft	0.23	337.50	0,07	112.50	0.30	450.00
ALUMINO-THERMIC WELDS	35	ea	3.00	105.00	37.50	1312.50	40.50	1417.50
TRENCH	1000	ft	---	---	4.50	4500.00	4.50	4500.00
SUBTOTAL				41494.50		21855.00		63349.50
10% MISC. MATERIALS & LABOR				4149.00		2185.00		6334.00
SUBTOTAL				45643.50		24040.50		69684.00
30% CONSTRUCTION PROFIT				13693.05		7212.15		20905.20
TOTAL				59336.55		31252.65		90589.20

S/N 0105-LF-010-1335
★ G.P.O.: 1979-689-016/4302

TABLE NO. I-A

SOIL RESISTIVITIES

SECTION A-1

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth	Depth	Depth
1.	East side of Lehua Ave. 300' NE of Tank 587	12000	8600	3600
2.	North of Lehua Elementary School	8000	2600	880
3.	700' East of Rdg. #2, near Freeway overpass H-1	4600	3200	1000
4.	1000' Southeast on Line from Rdg. #3	1400	2600	8400
5.	900' Southeast on Line from Rdg. #4	1200	620	400
6.	500' Northwest of Rectifier #12, near Pearl Harbor Park	1000	620	200
7.	Near Rectifier #12 at Pearl Harbor Park	340	420	240
8.	800' Southeast of Rdg. #7 Northwest of Bridge	350	220	200
9.	300' Southeast of Kanuku Street	320	520	360
10.	500' South of Kaonohi Street	250	160	200
11.	600' Southeast of Rdg. #10, NW of Bridge	220	620	440
12.	800' Southeast of Rdg. 11	130	130	200
13.	Northwest of Aiea Kai Way Street	210	320	400
14.	100' Northwest of Honomanu Street	220	200	860
15.	900' Southeast of Rdg. #14	1200	440	280
16.	NW of Aiea Stream Bridge near Standard Oil Rectifier	16000	3200	440
17.	North of VC-39	7000	3400	1920
18.	200' South of Rdg. #17, near Standard Oil and HIRI Pump Stations	5500	4400	1000
19.	On Line W of Aloha Stadium	8500	4400	400

20.	On Line NE of Aloha Statium	3600	4400	4000
21.	SW of Aiea Elementary School	7500	2400	880
22.	SE of Aiea Elementary School	6500	3600	2600
23.	East side of H-1	7000	3100	1200
24.	500' SE on Line from Rdg. #23	9000	2400	840
25.	Near Test Station at Halawa Heights	9000	2800	2200
26.	Near Halawa Heights Rd. S of Ulune St.	10000	3600	3200
27.	Near Halawa Heights Rd. & Ulune St.	2500	1800	3000
28.	Near Iwaiwa St. & Halawa Crusher St.	3600	4600	3200
29.	200' W of Rectifier #13	16000	4500	3200
30.	500' on Line SE of Rectifier #13	1200	5600	4800
31.	500' E on Line from Rdg. #30	19000	16000	12000
32.	200' W of Adit 3	1900	2400	2800
33.	300' E of Adit 3	1600	4500	3200
34.	500' E on Line from Rdg. 33	3000	4000	4000
35.	500' E on Line from Rdg. 34	12000	9000	6600
36.	500' E on Line from Rdg. 35	4500	6800	6000
37.	500' E on Line from Rdg. 36	13500	18000	9200
38.	500' E on Line from Rdg. 37	32500	3000	44000
39.	500' E on Line from Rdg. 38	15500	9000	4800
40.	500' E of Rdg. 39	23000	26000	14000
41.	500' E of Rdg. 40	19000	41000	64000
42.	500' E of Rdg. 41, near Adit 6	8000	14000	8400

TABLE NO. I-B

"AS FOUND"

PIPE-TO-SOIL POTENTIAL MEASUREMENTS

SECTION A-1

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	Bldg. S777	
	16" JP-5 above ground side of ins.	- 660
	16" JP-5 below ground side of ins.	- 740
2.	Existing test point with two #8 test leads in conduit and mounted on concrete post SE of Hale Mohalu Hospital	- 865
3.	At bridge SE of Hale Mohalu Hospital	
	16" JP-5	- 780
	42" Cast Iron Water Main	- 300
	4" Standard Oil line	-1500
	8" Standard Oil line	-1500
	8" Standard Oil line	-1330
4.	At bridge N of Hawaii Power Plant Tanks	
	16" JP-5	- 995
	42" Cast Iron Water Main	- 380
	4" Standard Oil line	-1630
	8" Standard Oil line	-1630
	8" Standard Oil line	-1460
5.	At bridge S of Hawaii Power Plant	
	16" JP-5	- 990
	42" Cast Iron Water Main	- 410
	4" Standard Oil line	-1600
	8" Standard Oil line	-1600
	8" Standard Oil line	-1430
6.	VC-37 at bridge, approximately 650' SE of Rdg. #5	
	16" JP-5	-1020
7.	At bridge near VC-37	
	16" JP-5	- 775

	42" Cast Iron Water Main	- 495
	4" Standard Oil line	-1440
	8" Standard Oil line	-1440
	8" Standard Oil line	-1380
8.	At bridge SE of Pearl Harbor Park	
	16" JP-5	- 775
	42" Cast Iron Water Main	- 495
	4" Standard Oil line	-1440
	8" Standard Oil line	-1440
	8" Standard Oil line	-1380
9.	VC-38	
	16" JP-5 line	- 880
10.	At bridge near VC-38	
	16" JP-5	- 880
	42" Cast Iron Water Main	- 535
11.	At bridge, approximately 600' SE of Rdg. #10	
	16" JP-5 line	- 865
	42" Cast Iron Water Main	- 495
	4" Standard Oil line	-1590
	8" Standard Oil line	-1590
12.	Existing Test Station with two #8 test leads, approximately 100' E of Rdg. #11	- 860
13.	At bridge, approximately 500' E of Rdg. #12	
	16" JP-5	- 815
	42" Cast Iron Water Main	- 705
	4" Standard Oil line	-1555
	8" Standard Oil line	-1555
	8" Standard Oil line	-1350
14.	Aiea Stream Bridge	
	16" JP-5 line	-1180
	42" Cast Iron Water Main	- 425
	4" Standard Oil line	-2010
	8" Standard Oil line	-1800
	8" Standard Oil line	-1270
15.	VC-39 N of NSC	-1270

16.	Standard Oil fenced enclosure, approximately 100' SE of Rdg. #15	
	8" Standard Oil line	
	Above ground side of insulator	- 320
	Under ground side of insulator	-1485
17.	HIRI Station 80' S of Rdg. #16	
	Southern Cal. side of insulator	- 395
	HIRI side of insulator	-1295
18.	2" Vent Pipes from casing W of Aloha Stadium	- 940
19.	2" Vent Pipes from casing NE of Aloha Stadium	- 455
20.	Gas Manhole S of Aiea Elementary School	- 755
21.	VC-E of Aiea Elementary School	
	16" JP-5 line	- 755
	8" X-tru Coat Gas Line	- 780
22.	VC in Navy Housing Area	
	16" JP-t line	-1060
	8" X-tru Coat Gas Line	- 820
23.	Water PRV near Building 22	- 445
24.	Existing Test Station in Navy Housing Area near Halawa Heights Drive with two #8 test leads	- 950
25.	2" Vent Pipe from casing at Ulune St. & Halawa Crusher St.	- 480
26.	2" Vent Pipe from casing near Iwalwa St. & Halawa Crusher St.	- 480
27.	2" Vent Pipe from casing near Iwalwa St. & Halawa Crusher St.	- 155
28.	Existing test station with two test leads, approximately 100' E of Iwalwa St. on N side of Crusher St.	-1190
29.	2" Vent pipe from casing E of bridge on Halawa Crusher St.	- 300
30.	VC-40, W of Rectifier #13	-1440
31.	Existing Test Station with two test leads, approximately 738' W of Adit #6	- 670
32.	Tank 355	
	Above ground side of Insulator	- 310
	Under ground side of Insulator	- 645
33.	Adit #6	
	16" JP-5 line	

Above ground side of Insulator	- 430
Under ground side of Insulator	- 580
8" Sludge Line	
Above ground side of Insulator	- 440
Under ground side of Insulator	- 580
2" Water Line	
Above ground side of Insulator	- 440
Under ground side of Insulator	- 380

TABLE NO. I-C

CURRENT TEST NO. 1

SECTION A-1

Location: Rectifier #13, near VC-40

Rectifier D.C. Output: 10 volts - 9.5 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Bldg. S777			
	16" JP-5 line			
	Above ground side of insulator	- 660	- 660	0
	Under ground side of insulator	- 705	- 740	35
2.	Existing test point with two #8 test leads in conduit & mounted on concrete post	- 840	- 865	25
3.	At Bridge, SE. of Hale Mohalu Hospital			
	16" JP-5 line	- 760	- 780	20
	42" Cast Iron Water Main	- 300	- 300	0
	4" Standard Oil line	-1500	-1500	0
	8" Standard Oil line	-1500	-1500	0
	8" Standard Oil line	-1330	-1330	0
4.	At Bridge, N. of Hawaii Power Plant Tanks			
	16" JP-5 line	- 955	- 955	0
	42" Cast Iron Water Main	- 380	- 380	0
	4" Standard Oil line	-1630	-1630	0
	8" Standard Oil line	-1630	-1630	0
	8" Standard Oil line	-1460	-1460	0
5.	At Bridge, S. of Hawaii Power Plant Tanks			
	16" JP-5	- 950	- 990	40
	42" Cast Iron Water Main	- 405	- 410	5
	4" Standard Oil line	-1600	-1600	0
	8" Standard Oil line	-1430	-1430	0

6.	VC-37, approximately 650' SE. of Rdg. #5			
	16" JP-5	- 980	-1020	40
7.	At Bridge near VC-37			
	16" JP-5 line	- 980	-1020	40
	42" Cast Iron Water Main	- 510	- 510	0
	4" Standard Oil line	-1660	-1660	0
	8" Standard Oil line	-1660	-1660	0
	8" Standard Oil line	-1550	-1550	0
8.	At Bridge, SE. of Pearl Harbor Park			
	16" JP-5 line	- 730	- 775	45
	42" Cast Iron Water Main	- 495	- 495	0
	4" Standard Oil line	-1440	-1440	0
	8" Standard Oil line	-1440	-1440	0
	8" Standard Oil line	-1380	-1380	0
9.	VC-38 near Bridge	- 775	- 880	105
10.	At Bridge near VC-38			
	16" JP-5 line	- 775	- 880	105
	42" Cast Iron Water Main	- 535	- 535	0
11.	At Bridge, approximately 600' SE of Rdg. #10			
	16" JP-5 line	- 775	- 865	90
	42" Cast Iron Water Main	- 495	- 495	0
	4" Standard Oil line	-1590	-1590	0
	8" Standard Oil line	-1590	-1590	0
12.	Existing test station with two #8 test leads approximately 100' E. of Rdg. #11	- 775	- 860	95
13.	At Bridge, approximately 500' E. of Rdg. #12			
	16" JP-5 line	- 755	- 815	60
	42" Cast Iron Water Main	- 700	- 705	5
	4" Standard Oil line	-1575	-1555	-20*
	8" Standard Oil line	-1575	-1555	-20*
	8" Standard Oil line	-1360	-1350	-10*
14.	Aiea Stream Bridge			
	16" JP-t line	-1020	-1180	-40*

	42" Cast Iron Water Main	- 420	- 425	5
	4" Standard Oil line	-2010	-2101	0
	8" Standard Oil line	-2010	-2010	0
	8" Standard Oil line	-1800	-1800	0
15.	VC-39, N. of NSC, PWC	- 890	-1270	380
16.	Standard Oil fenced enclosure, approximately 100' SE. of Rdg. #15			
	8" Standard Oil line			
	Above ground side of insulator	- 325	- 320	-5*
	Under ground side of insulator	-1480	-1485	5
17.	HIRI Station 80' S. of Rdg. #16			
	So. Cal. side of insulator	- 400	- 395	-5*
	HIRI side of insulator	-1300	-1295	-5*
18.	2" Vent Pipe from casing, W. of Aloha Stadium	- 840	- 940	100
19.	2" Vent Pipe from casing, NE. of Aloha Stadium	- 470	- 455	-15*
20.	Gas Manhole, S. of School	- 875	- 755	-120*
21.	VC at Aiea Elementary E. of School Bldg.			
	16" JP-5 line	- 760	-1030	270
	8" X-tru Coat line (Gas)	- 840	- 780	-60*
22.	VC in Navy Housing Area			
	16" JP-t line	- 770	-1060	290
	8" X-tru Coat Line (Gas)	- 880	- 820	-60*
23.	Water PRV near Rdg. #22	- 450	- 440	-10*
24.	Existing test station with two #8 test leads in Navy Housing area near Halawa Hts. Road	- 680	- 950	270
25.	2" Vent pipe from casing at corner of Ulune St. & Halawa Hts. Road	- 445	- 470	25
26.	2" Vent pipe from casing near Halawa Crusher Rd. & Ulune St.	- 450	- 480	30
27.	2" Vent pipe from casing near Halawa Crusher Rd. & Iwaaiwa St.	- 155	- 155	0
28.	Existing test station with two #8 test leads approximately 100'			

	E. of Iwaiwa St. on N. side of Halawa Crusher Rd.	- 670	-1190	520
29.	2" Vent pipe from casing on Halawa Crusher Rd. near Bridge	- 310	- 300	-10*
30.	VC-40 W. of Rectifier #13	- 700	-1440	740
31.	Existing test station with two #8 test leads approximately 738' W. of Adit 6	- 480	- 670	190
32.	Tank 355			
	Above ground side of insulator	- 300	- 310	10
	Below ground side of insulator	- 505	- 645	150
33.	Adit 6			
	16" JP-5 line			
	Above ground side of insulator	- 480	- 430	-50*
	Below ground side of insulator	- 515	- 580	65
	8" Sludge line			
	Above ground side of insulator	- 490	- 440	-50*
	Below ground side of insulator	- 520	- 580	60
	2" Water Line			
	Above ground side of insulator	- 490	- 440	-50*
	Below ground side of insulator	- 435	- 380	-55*
34.	10" Fresh Water and 10" fuel line at Adit #3	- 465	- 490	35

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of the test current.

TABLE NO. I-D

CURRENT TEST NO. 2

SECTION A-1

Location:	Test station approximately 738' W. of Adit 6
Number of anodes used for current test:	Ten steel rods as temporary anodes.
Negative connection:	To existing test leads in test box.
Test Rectifier D.C. Output:	2.5 amps D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Existing test station with two #8 test leads in Navy Housing area near Halawa Heights Drive	- 950	-1110	160
2.	Existing test station with two #8 test leads approximately 100' E. of Iwaiwa St. on N. side of Halawa Crusher Rd.	-1180	-1220	40
3.	VC-40, W. of Rectifier #13	-1400	-1400	0
4.	Existing test station with two #8 test leads approximately 738' W. of Adit 6	- 700	-1280	580
5.	Adit 6			
	16" JP-5 line			
	Above ground side of insulator	- 475	- 445	-35*
	Below ground side of insulator	- 580	- 640	60
	8" Sludge line			
	Above ground side of insulator	- 475	- 445	-35*
	Below ground side of insulator	- 580	- 640	60
	2" Water line			
	Above ground side of insulator	- 480	- 460	-20*
	Below ground side of insulator	- 310	- 300	-10*

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of the test current.

TABLE NO. I-E

CURRENT TEST NO. 3

SECTION A-1

Location: Rectifier #12 near Pearl Harbor Park.

Number of anodes used for Current Test: Two 4' pieces of channel iron 10' off shore line.

Test Rectifier D.C. Output: 13 amps D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Bldg. S777			
	16" JP-5 line			
	Above ground side of insulator	- 695	- 700	5
	Below ground side of insulator	- 700	- 780	80
2.	Existing test point with two #8 test leads in conduit and mounted on concrete post SE. of Hale Mohalu Hospital	- 900	-1040	140
3.	At Bridge, SE. of Hale Mohalu Hospital			
	16" JP-5 line	- 820	- 960	140
	42" Cast Iron Water Main	- 305	- 280	-25*
	4" Standard Oil line	-1570	-1520	-50*
	8" Standard Oil line	-1570	-1520	-50*
	8" Standard Oil line	-1370	-1360	-10*
4.	At Bridge, S. of Hawaii Power Plant			
	16" JP-5 line	- 980	-1180	200
	42" Cast Iron Water Main	- 360	- 380	20
	4" Standard Oil line	-1620	-1020	-600
	8" Standard Oil line	-1620	-1620	0
	8" Standard Oil line	-1450	-1450	0
5.	VC-37 by Bridge, approximately 650' SE. of Rdg. #4			
	16" JP-5 line	-1040	-1040	0

6.	At Bridge near VC-37			
	16" JP-5 line	-1040	-1040	0
	42" Cast Iron Water Main	- 515	- 510	-5*
	4" Standard Oil line	-1700	-1670	-30*
	8" Standard Oil line	-1700	-1690	-10*
	8" Standard Oil line	-1575	-1570	-5*
7.	At Bridge approximately 600' SE. of VC-38			
	16" JP-5 line	- 915	-1050	135
	42" Cast Iron Water Main	- 495	- 490	-5*
	4" Standard Oil line	-1510	-1500	-10*
	8" Standard Oil line	-1510	-1500	-10*
8.	Aiea Stream Bridge			
	16" JP-5 line	-1240	-1340	100
	42" Cast Iron Water Main	- 425	- 425	0

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of the test current.

TABLE NO. I-F

CURRENT TEST NO. 4

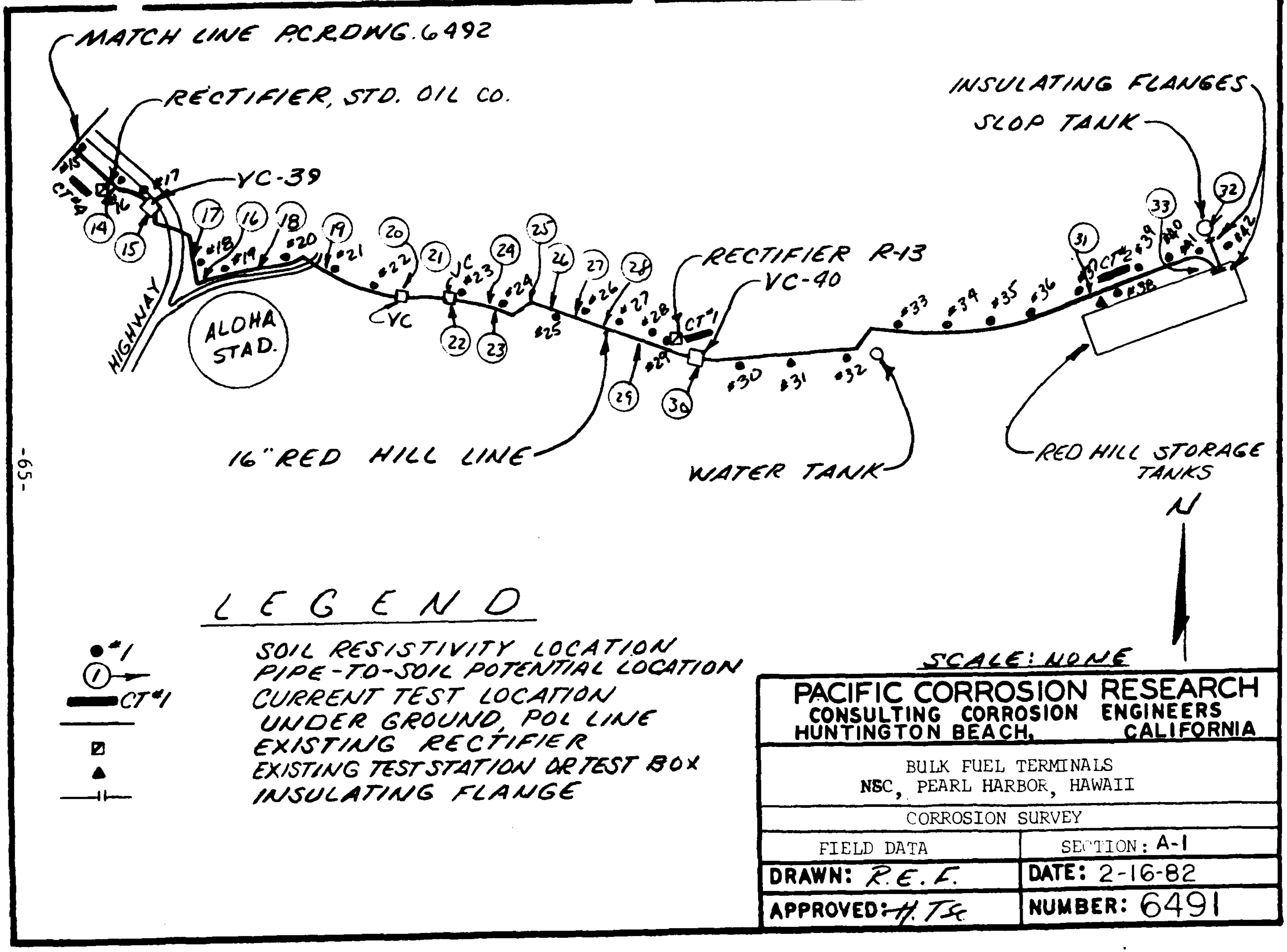
SECTION A-1

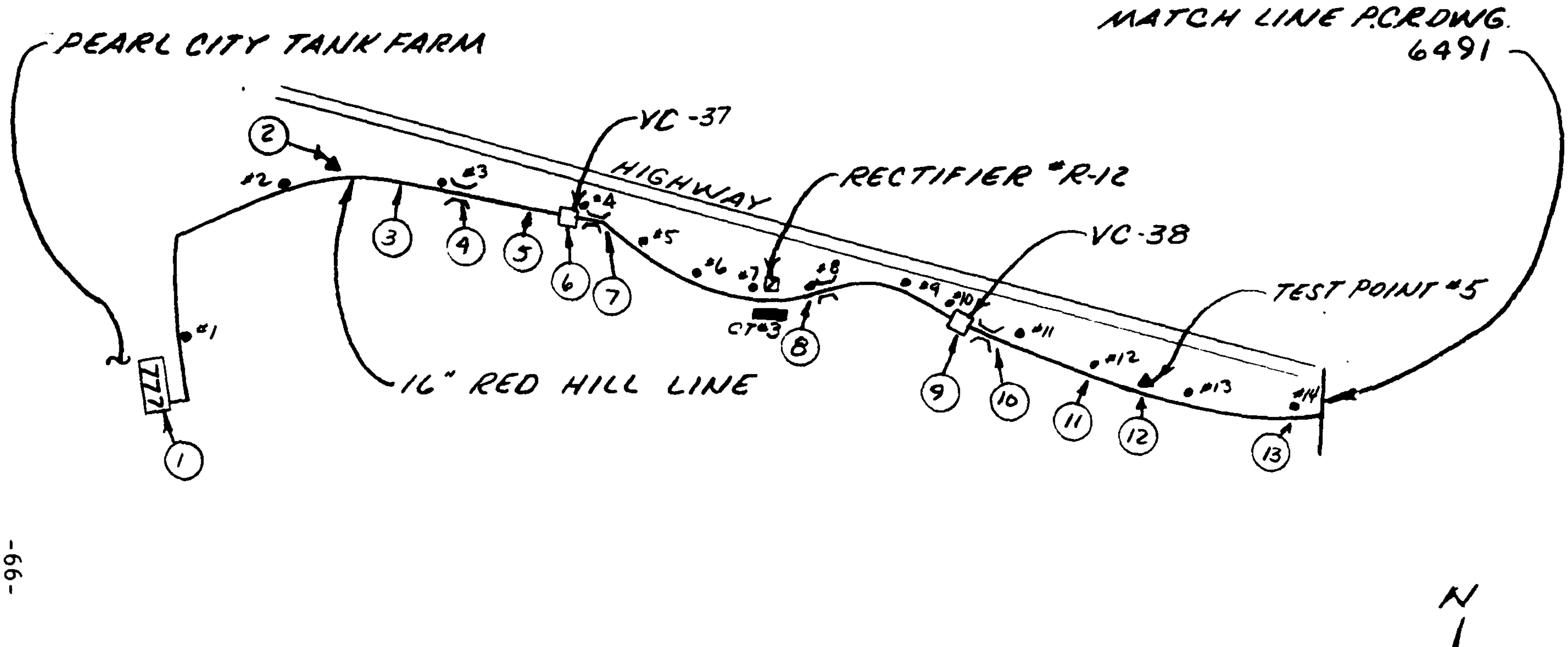
Location: Standard Oil Company Rectifier NW. of VC-39 near Aiea Stream Bridge

Test Rectifier D.C. Output: Unknown D.C. Output

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	At Bridge, SE. of Pearl Harbor Park			
	16" JP-5 line	- 840	- 810	-30*
	42" Cast Iron Water Main	- 505	- 500	-5*
	4" Standard Oil line	-1330	-1440	110
	8" Standard Oil line	-1330	-1440	110
	8" Standard Oil line	-1330	-1380	50
2.	At Bridge, approximately 600' SE. of VC-38			
	16" JP-5 line	- 910	- 895	-15*
	42" Cast Iron Water Main	- 495	- 480	-15*
	4" Standard Oil line	-1250	-1520	270
	8" Standard Oil line	-1250	-1520	270
3.	Aiea Stream Bridge			
	16" JP-5 line	- 940	-1020	80
	42" Cast Iron Water Main	- 400	- 425	25
	4" Standard Oil line	-1200	-2010	810
	8" Standard Oil line	-1200	-2010	810
	8" Standard Oil line	-1180	-1800	620
4.	VC-39 N. of NSC, PWC	-1000	-1290	290
5.	Existing test station with two #8 test leads in Navy Housing area near Halawa Heights Drive	-1115	-1125	10

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of the test current.


MATCH LINE P.C.R.DWG. 6492
RECTIFIER, STD. OIL CO.
YC-39
INSULATING FLANGES
SLOP TANK
HIGHWAY
ALOHA STAD.
YC
YC
RECTIFIER R-13
VC-40
16" RED HILL LINE
WATER TANK
RED HILL STORAGE TANKS
N
LEGEND
SOIL RESISTIVITY LOCATION
PIPE-TO-SOIL POTENTIAL LOCATION
CURRENT TEST LOCATION
UNDER GROUND, POL LINE
EXISTING RECTIFIER
EXISTING TEST STATION OR TEST BOX
INSULATING FLANGE
SCALE: NONE
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA
BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII
CORROSION SURVEY
FIELD DATA
SECTION: A-1
DRAWN: R.E.F.
DATE: 2-16-82
APPROVED: H. Ts
NUMBER: 6491

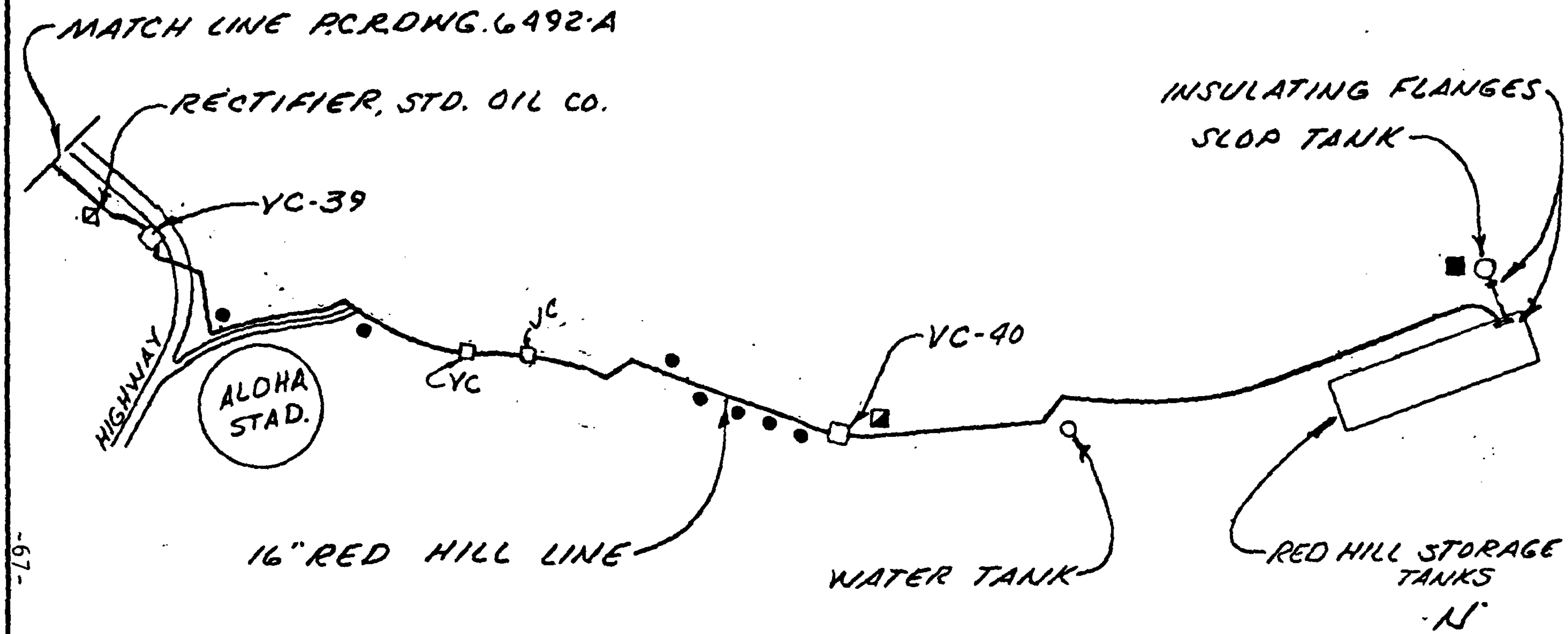


LEGEND

- •#1 SOIL RESISTIVITY LOCATION
- (1)→ PIPE-TO-SOIL POTENTIAL LOCATION
- CT#1 CURRENT TEST LOCATION
- UNDER GROUND POL LINE
- ▲ EXISTING TEST STATION OR TEST BOX
- ☒ EXISTING RECTIFIER

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: A-1
DRAWN: R.E.F.	DATE: 2-12-82
APPROVED: A.T.S.	NUMBER: 6492

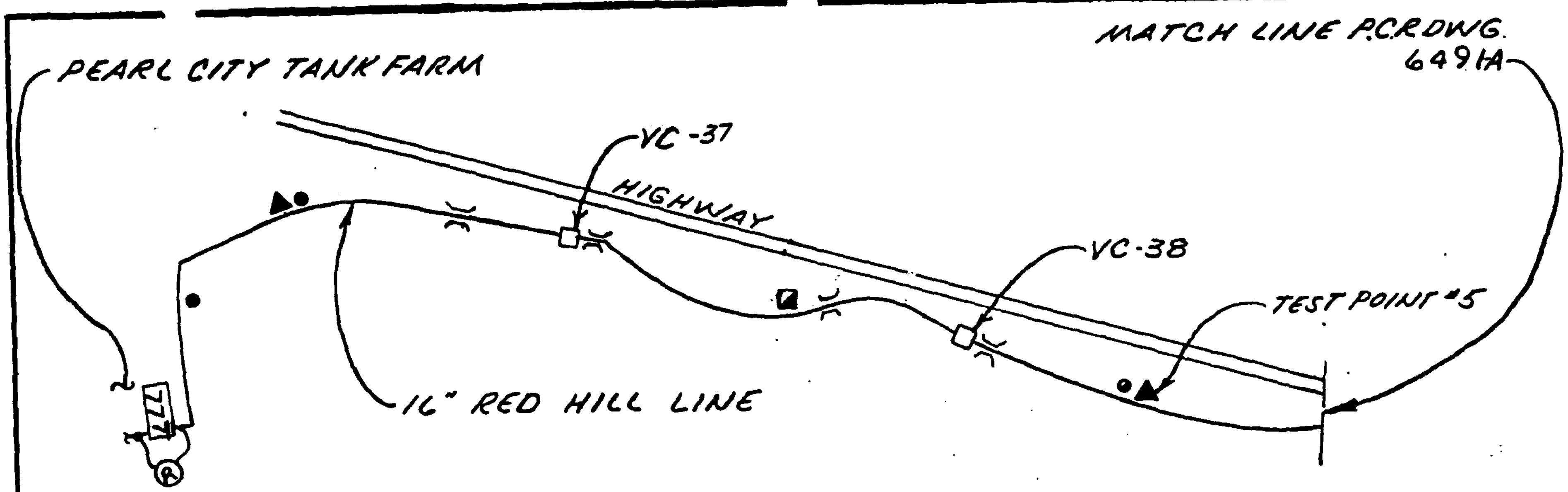


LEGEND

- REPLACE EXISTING RECTIFIER R-13 WITH A NEW OIL COOLED RECTIFIER AND INSTALL GRAPHITE ANODES.
- INSTALL NEW OIL COOLED RECTIFIER AND INSTALL HIGH SILICON IRON TUBULAR ANODES.
- INSTALL NEW TEST BOX AND INSTALL PREPACKAGED MAGNESIUM ANODES.

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED C.P. SYS.	SECTION: A-1
DRAWN: R.E.F.	DATE: 2-16-82
APPROVED: H. Tsai	NUMBER: 6491-A



LEGEND

- ▲ EXISTING TEST POINT
- INSTALL INSULATING FLANGE SET AND RESISTANCE BOND STATION.
- ● INSTALL NEW TEST BOX AND INSTALL PREPACKAGED MAGNESIUM ANODES.
- INSTALL NEW TEST BOX AND INSTALL ZINC ANODES.
- REPLACE EXISTING RECTIFIER R-12 WITH A NEW OIL COOLED RECTIFIER AND INSTALL HIGH SILICON IRON TUBULAR ANODES

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED C.P. SYS.	SECTION: A-1
DRAWN: R.E.F.	DATE: 2-12-82
APPROVED: A.T.S.	NUMBER: 6492-A

SECTION A-2

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX

INCLUDING ONE 16" AVGAS LINE FROM

VICTOR DOCKS TO PEARL CITY TANK FARM

SECTION A-2

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX

INCLUDING ONE 16" AVGAS LINE FROM

VICTOR DOCKS TO PEARL CITY TANK FARM

SECTION A-2

SUMMARY

1. Conclusions:

Based on the field data obtained, the following results were observed:

A. The soil resistivity measurements obtained in the field show a non-uniform environment. Where pipelines traverse areas of varying resistivity, corrosion will take place in the area of the lower resistivity.

B. The POL lines of Section A-2 are electrically continuous with the POL lines of Sections A-3, A-5 and C-1.

C. The southern portion of the POL lines,(Section A-2)were found to be cathodically protected, but the northern portion of the POL lines are not at a protective potential level.

D. An insulator was found to be installed at each of the following locations:

(1) The 18" JP-4 line at Fuel Station S-777.

(2) The 16" Avgas line in VC-1 and VC-1A.

(3) The 14" JP-4 line in VC-H.

E. Approximately 80,000 sq. ft. of coated steel POL lines are to be considered for cathodic protection, in Section A-2. It is estimated that an additional current of 50 amperes D.C. will be required to provide cathodic protection for these lines.

F. No test stations were found installed on the POL lines (approximately 3,200') from west of Building 72 to east of Building 724.

G. During this survey, interference was found on an unknown metallic line, on the east side of Lehua Avenue and the POL lines. A resistance bond station was found installed on the west side of Building 72. A current drain of 620 ma was measured.

2. <u>Recommendations:</u>

A. The results of the current tests indicate the current demand for the underground POL lines will require three additional magnesium anode beds and one impressed current anode bed.

(1) <u>Magnesium Anode Bed:</u> One magnesium anode bed, consisting of five (5) 50 lb. prepackaged anodes and a test box, should be installed at each of the following locations:

a. Anode Bed #1 - Southeast of Building 75

b. Anode Bed #2 - Northeast of Building 849

c. Anode Bed #3 - Southeast of Building 712

(2) <u>Impressed Current Anode Bed:</u> It is recommended that a new anode bed, consisting of one (1) oil cooled rectifier and ten (10) 4-3/4"x84" high silicon iron tubular anodes, be installed south of Tank #3 (S88). This anode bed will provide protection for portions of Sections A-2, A-5 and C-1.

B. To eliminate interference that has effected the unknown metallic line on the east side of Lehua Avenue, it will be necessary to install a new resistance bond station between the unknown line and the POL lines on the west side of Building 74.

SECTION A-2

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX, INCLUDING ONE 16" AVGAS LINE FROM VICTOR DOCKS TO PEARL CITY TANK FARM

1. Description.

A. Lines to be Protected:

(1) From Fuel Station S-777 to VC-13

a. 18" JP-4 Line - Coated Steel

(2) From VC-12 to VC-13

a. 12" Ballast Line - Coated Steel

(3) From VC-1B (E of Fuel Station S-777) to VC-5

a. 8" JP-5 Line - Coated Steel

(4) From VC-1 and VC-1A to NW of Victor Dock 4

a. 16" Avgas Line - Coated Steel

(5) From VC-9 to VC-H

a. 14" JP-4 Line - Coated Steel

(6) From VC-10 to VC-B

a. 10" Avgas Line - Coated Steel

B. Existing Cathodic Protection System:

This section of POL lines were originally designed to be protected by two existing oil cooled Rectifiers #11 and #3.

(1) Rectifier #11

a. Rectifier Location: Rectifier #11 is located southwest of the Pearl City Tank Farm.

b. Rectifier Unit: Mfg. - Electrical Facilities, Inc. Oakland, Ca.

Serial No. - Unknown (no name plate was found)

D.C. Capacity - 20 V 50 A
Operating at - Tap setting 5-4
D.C. Output - 3.5 V, 13 A
Date Recorded - October 10, 1981

c. Anode Bed Location: Three sections of railroad tracks were installed 5' east Kalapo Canal and approximately 350' north of Waipuna Avenue.

(2) <u>Rectifier #3</u>

a. Rectifier Location: Rectifier #3 is located south of Building 691 and between Victor Docks #1 and #2.

b. Rectifier Unit: Mfg. - Electrical Facilities, Inc.
Serial No. - 5033571
D.C. Capacity - 8 V, 50 A
Operating at - Tap setting 5-4
Date Recorded - October 10, 1981

c. Anode Bed Location: Two sections of railroad track were installed approximately 30' south of the shore line.

2. <u>Field Work and Evaluation of Data</u>.

A. Soil Resistivity Measurements: A total of sixteen sets of measurements were obtained at representative locations as shown in Table No. II-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	34	Severe
Medium	2,000 - 10,000	25	Moderate
High	10,000 - 30,000	29	Slight unless other factors are pronounced
Very High	Above - 30,000	12	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on underground metallic structures. Thirty-four percent of the measurements obtained were in the severe category and twenty-five percent were in the medium or moderate category.

B. "As Found" Pipe-to-Soil Potentials: "As found" pipe-to-soil potentials were obtained at each valve chamber and at each test station. The results of these measurements indicate that the POL lines in the area adjacent to the Pearl City Tank Farm are not at a protective potential level, but the POL lines north of Victor Docks are cathodically protected. The results of these measurements are shown in Table No. II-B.

C. Current Tests: Two current tests were conducted on this section of POL lines. Pipe-to-soil potentials were obtained at the same locations as "as found" potentials with the rectifier "off" and "on".

(1) Current Test No. 1 - This current test was conducted with existing Rectifier #3 turned "off" and "on". During this test, Rectifier #3 was operating at a tap

setting of 5 (coarse) - 4 (fine) providing 3.5 volts and 13 amperes D.C.. The results of this test are shown in Table No. II-C.

(2) Current Test No. 2 - This current test was conducted on the POL lines under the following conditions: .

a. Existing Rectifier #3 was operating at a tap setting of 5 (coarse) - 4 (fine), providing 3.5 volts and 13 amperes D.C.. During performance of this test, this rectifier was turned "on" all the time.

b. Existing Rectifier #11 was operating at a tap setting of 10 (coarse) - 4 (fine), providing 7.5 volts and 27.5 amperes D.C.. Pipe-to-soil potentials were obtained with this rectifier turned "off" and "on". The results of this test are shown in Table No. II-D.

Based on the data obtained, the following results were observed:

(i) The POL lines of Section A-2 are electrically continuous with the POL lines of Sections A-3, A-5, and C-1.

(ii) The southern portion of the POL lines in the area adjacent to Victor Docks was found to be cathodically protected by the Rectifier #3. Rectifier #11 does not provide adequate protection for the northern portion of the POL lines.

(iii) The current requirements for Section A-2 will not be high.

(iv) Interference was found on unknown metallic lines on the east side of the 16" Avgas line between Building 72 and Farm Street from the existing anode bed of Rectifier #11. A resistance bond station was found to be installed west of Building 72 with test leads connected to the 16" Avgas line and the unknown line. A drain current of 620 ma was found to flow from the unknown line to the 16" Avgas line.

D. <u>Inspection of Pipelines</u>:

All POL lines of Section A-2 are underground. No excavation was made during this survey for the lines underground.

E. <u>Leak History</u>:

The leak history was discussed with Mr. John Kimi, Mr. Albert Wong and Pearl City Tank Farm personnel. Approximately 90% of the POL lines were installed in 1954. Only two leaks on the 16" Avgas line west of Building 72 were found and repaired in 1965 and 1981. These leaks were reported to be a result of external corrosion. The leak locations are shown on PCR Drawings No. 6493, 6494 and 6495. We were advised that the 10" mogas and avgas lines from VC-10 to Victor Docks have been abandoned in place.

3. <u>Conclusions</u>.

Based on the field data obtained, the following results were observed:

A. The results of soil resistivity measurements indicate that

34% of the readings are in the severe category and 25% are in the moderate and 29% are in the slight category. The measurements obtained in the field show a non-uniform environment. Where pipelines traverse areas of varying resistivity, corrosion will take place in the area of lower resistivity.

B. The POL lines of Section A-2 are electrically continuous with the POL lines of Sections A-3, A-5 and C-1.

C. The southern portion of the POL lines, Section A-2, were found to be cathodically protected, but the northern portion of the POL lines are not at a protective potential level.

D. An insulator was found to be installed at each of the following locations:

(1) The 18" JP-4 line at Fuel Station S-777.

(2) The 16" Avgas line in VC-1 and VC-1A.

(3) The 14" JP-4 line in VC-H.

E. The results of current tests conducted, indicated that the current demand will be moderate. Approximately 80,000 sq. ft. of coated steel POL lines are to be considered for cathodic protection in Section A-2. The current tests also indicated that the coating of the POL lines of this section are in good condition. It is estimated that an additional current of 50 amperes D.C. will be required to provide cathodic protection for these lines.

F. No test stations were found installed on the POL lines (approximately 3200') from west of Building 72 to east of Building 724.

G. During this survey, interference was found on an unknown metallic line on the east side of Lehua Avenue and the POL lines. A resistance bond station was found installed on the west side of Building 72. A current drain of 620 ma was measured.

4. Recommendations.

A. The results of the current tests indicate that the current demand for the underground POL lines will require three additional magnesium anode beds and one impressed current anode be.

(1) Magnesium Anode Bed: One magnesium anode bed consisting of five 50 lb. prepackaged anodes and a test box should be installed at each of the following locations:

a. Anode Bed #1 - Southeast of Building 75

b. Anode Bed #2 - Northeast of Building 849

c. Anode Bed #3 - Southeast of Building 712

It is recommended that two test leads be connected to each POL line and terminated in a test box at these locations.

(2) Impressed Current Anode Bed:

a. It is recommended that a new anode bed consisting of one oil cooled rectifier and ten 4 3/4" x 84" high silicon iron tubular anodes be installed south of Tank 3 (S88). This anode bed will provide protection for portions of Sections A-2, A-5 and C-1.

b. Existing Rectifier #11 and its existing anode bed should be replaced as recommended in Section A-5.

B. To eliminate the interference that has effected the unknown metallic line on the east side of Lehua Avenue, it will be necessary to install a new resistance bond station between the unknown line and the POL lines on the west side of Building 74.

NOTE The locations of the pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawings No. 6493, 6494 and 6495.

The recommended C.P. systems of Section A-2 are shown on PCR Drawings No. 6483-A, 6494-A and 6495-A.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1 1982

SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION A-2

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ______

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
4 3/4"x84" HI SILICON IRON TUBULAR ANODES	10	ea	720.00	7200.00	180.00	1800.00	900.00	9000.00
OIL COOLED RECTIFIER	1	ea	1950.00	1950.00	600.00	600.00	255.00	2550.00
50 LB. PREPACKAGED MAGNESIUM ANODES	15	ea	225.00	3375.00	150.00	2250.00	375.00	5625.00
#2 HMP STRANDED COPPER CABLE	300	ft	1.50	450.00	0.15	45.00	1.65	495.00
#8 HMP STRANDED COPPER CABLE	200	ft	0.75	150.00	0.15	30.00	0.90	180.00
COAL COKE BREEZE	4000	lb	0.30	1200.00	0.08	320.00	0.38	1520.00
1" PVC CLASS 200, PLASTIC PIPE	800	ft	0.75	600.00	0.15	120.00	0.90	720.00
RESISTANCE BOND STATION	1	ea	150.00	150.00	300.00	150.00	300.00	300.00
CONCRETE PAD	1	ea	150.00	150.00	300.00	300.00	450.00	450.00
SPLIT BOLTS	30	ea	1.05	31.50	4.50	135.00	5.55	166.50
CONCRETE TEST BOXES/CAST IRON LIDS	4	ea	45.00	180.00	75.00	300.00	120.00	480.00
HOSE CONNECTION ADAPTERS	4	ea	7.50	30.00	7.50	30.00	15.00	60.00
0.01 OHM SHUNTS	3	ea	7.50	22.50	7.50	22.50	15.00	45.00
COAL TAR ENAMEL (1 GALLON CAN)	1	ea	22.50	22.50	45.00	45.00	67.50	67.50
BUTYL TAPE	2	rl	37.50	75.00	45.00	90.00	82.50	165.00
RUBBER TAPE	6	rl	4.50	27.00	7.50	45.00	12.00	72.00
PLASTIC TAPE	6	rl	4.50	27.00	7.50	45.00	12.00	72.00

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 2 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM CORROSION SURVEY, SECTION A-2

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
TERRA TAPE	350	ft	0.22	77.00	0.08	28.00	0.30	105.00
ALUMINO-THERMIC WELDS	12	ea	3.00	36.00	37.50	450.00	40.50	486.00
TRENCH	350	ft	-	-	4.50	1575.00	4.50	1575.00
SUBTOTAL				15753.00		8380.50		24134.00
10% MISC. MATERIALS & LABOR				1575.00		838.00		2413.00
SUBTOTAL				17328.00		9218.50		26547.00
30% CONSTRUCTION PROFIT				5198.55		2765.55		7964.10
TOTAL				22527.05		11984.05		34511.10

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

SECTION A-2

SOIL RESISTIVITIES

TABLE NO. II-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	E of Fuel Station S777	12000	2200	280
2.	E of VC-11	14000	2400	240
3.	E of VC-12	13000	2200	520
4.	E of VC-10	14000	2000	560
5.	400' S of Rdg. 4 near Bldg. 74	14000	1800	480
6.	50' from SE corner of Bldg. 75	19000	2800	480
7.	400' E of Rdg. 6	19000	3400	3200
8.	400' S of Rdg. 7	16000	12000	2000
9.	400' S of Rdg. 8	31000	20000	3600
10.	400' S of Rdg. 9, E of Bldg. 851	18000	18000	2800
11.	400' S of Rdg. 10, E of Bldg. 843	31000	20000	3200
12.	400' S of Rdg. 11, E of Bldg. 725	13000	7000	1640
13.	400' S of Rdg. 12, E of Bldg. 723	12000	6800	1520
14.	400' S of Rdg. 13, 100' W of Bldg. 710	39000	16000	1520
15.	400' S of Rdg. 14	1300	380	360
16.	400' S of Rdg. 15, at Victor Dock	1200	360	400

AD-A119 019 PACIFIC CORROSION RESEARCH INC HUNTINGTON BEACH CA F/G 13/8
A-E SERVICES TO PERFORM A CATHODIC PROTECTION SURVEY OF THE BUL--ETC(U)
JUN 82 N62742-81-C-0006

UNCLASSIFIED NL

2 OF 5
AD A
119019

SECTION A-2

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. II-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	Building S777	
	18" JP-4 Line	
	Above ground side of Insulator	- 665
	Under ground side of Insulator	- 755
2.	VC-1 & VC-1A	
	16" Avgas Line	
	Protected side of Insulator	- 760
	Unprotected side of Insulator	- 710
3.	VC-12	
	12" Ballast Line	- 740
4.	Existing Test Station, E side of Lehua St. and NE of Tank S94	
	Foreign Line side	- 920
	Navy side	- 950
5.	VC-10	
	10" Mogas to VC-1 & VC-1A	- 695
	10" Mogas to Victor Docks (valve dropped & abandoned)	- 525
6.	VC-9	
	14" JP-4 to Victor Docks	- 695
7.	Existing Test Station, E of Bldg. 724	-1040
8.	VC-4	
	14" JP-4, Tank Farm Side of Insulator	- 930
	10" JP-4, to Victor Dock #4	- 725
9.	Existing Test Station, N of VC-H with three test leads	- 930
10.	VC-13	
	All lines	-1030
11.	VC-B	
	All lines	-1080

SECTION A-2

CURRENT TEST NO. 1

TABLE NO. II-C

Location:	Existing Rectifier #3, South of Bldg. 691 & between Victor Docks #1 & #2
Number of anodes used for Current Test:	Three sections of railroad tracks installed approximately 30' off the shore line on the ocean floor
Negative Connection:	Existing
Rectifier D.C. Output:	3.5 volts - 13 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Bldg. S777			
	18" JP-4 Line			
	Above ground side of Insulator	-660	-665	5
	Below ground side of Insulator	-750	-755	5
2.	VC-1 & VC-1A			
	16" Avgas Line			
	Protected side of Insulator	-750	-760	10
	Unprotected side of Insulator	-710	-710	0
3.	VC-12			
	12" Ballast Line	-720	-740	20
4.	Existing Test Station, E side of Lehua St. & NE of Tanks S94			
	Foreign Line side	-880	-920	40
	Navy side	-890	-950	60
5.	VC-10			
	10" Mogas to VC-1 & VC-1A	-690	-695	5
	10" Mogas to Victor Docks (valve dropped & abandoned)	-525	-525	0
	10" Avgas to VC-1 & VC-1A	-690	-695	5
	10" Avgas to Victor Docks	-690	-695	5

6.	VC-9 14" JP-4 to Victor Docks	-690	-695	5
7.	Existing Test Station, E of Bldg. 724	-930	-1030	110
8.	VC-4 14" JP-4, Tank Farm side of Insulator	-880	-930	50
	10" JP-4 to Victor Dock #4	-710	-725	15
9.	Existing Test Station, N of VC-11 with three test leads	-880	-930	50
10.	VC-13 All Lines	-930	-1030	100
11.	VC-B All Lines	-970	-1080	110

SECTION A-2

CURRENT TEST NO. 2

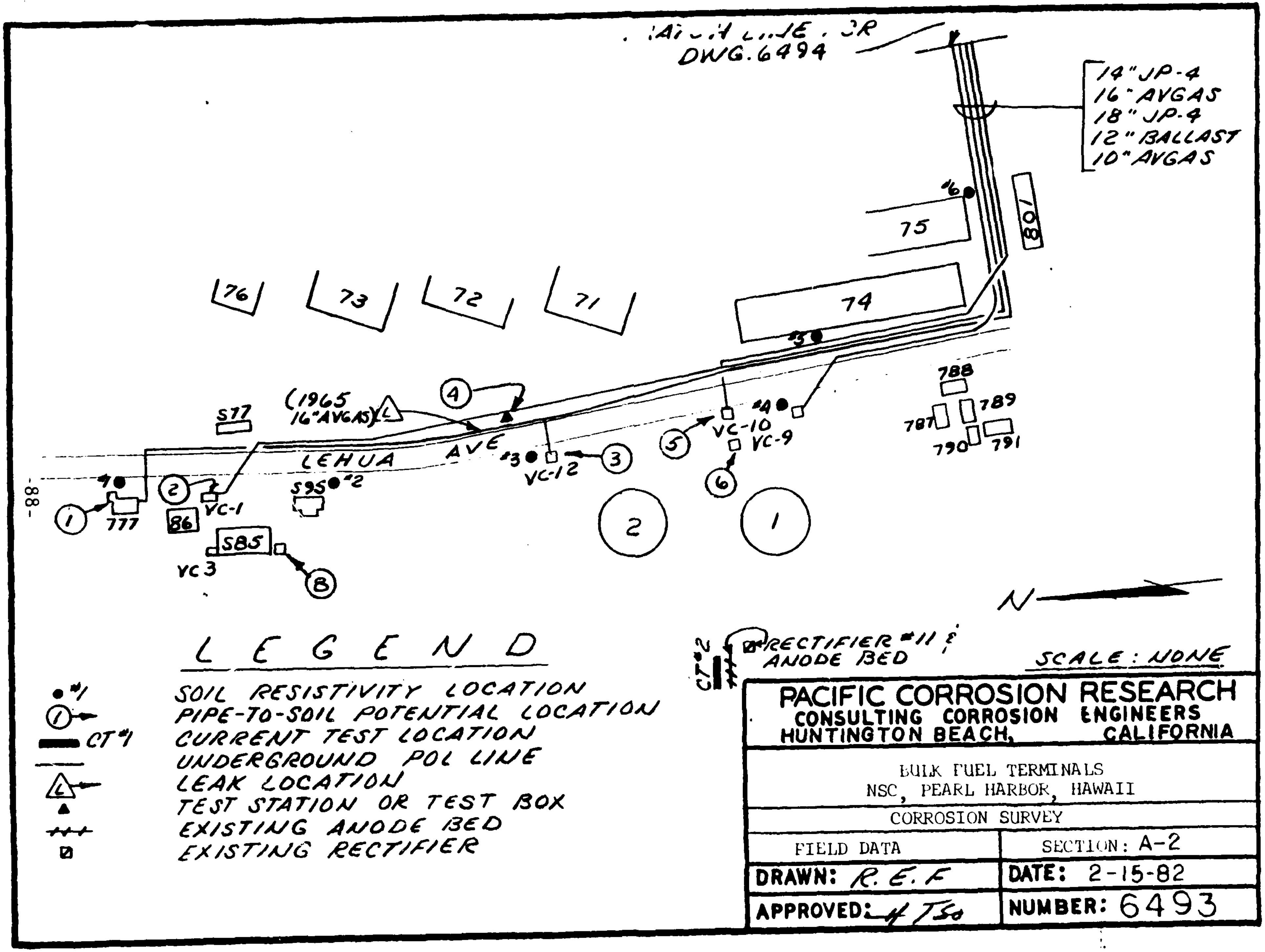
TABLE NO. II-D

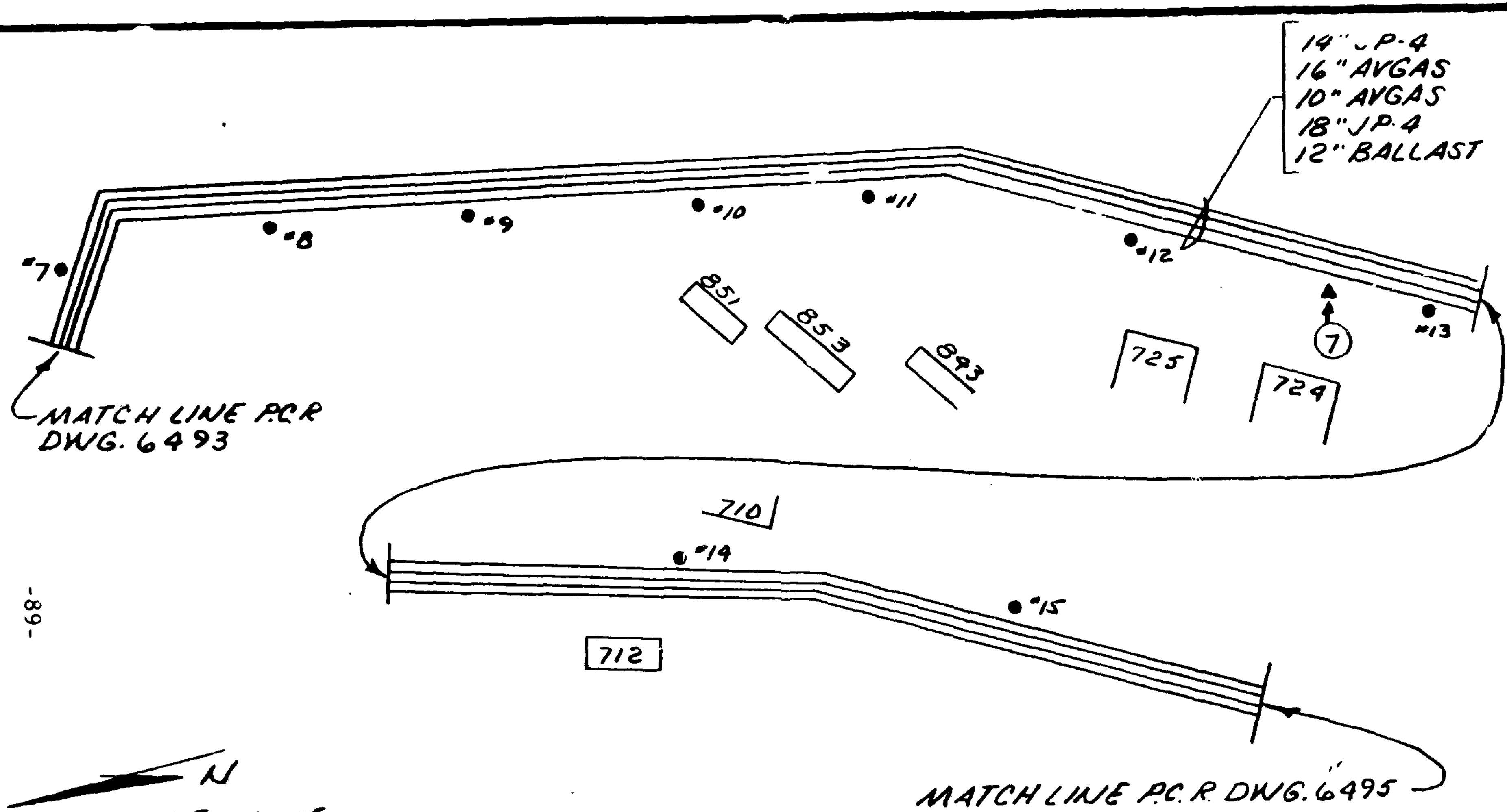
Location:	Existing Rectifier #11, Southwest corner of Pearl City Tank Farm.
Anodes used for Current test:	Existing anode bed.
Negative Connection:	Existing.
Rectifier D.C. Output:	The current output of existing Rectifier #11 was increased to 7.5 volts - 27.5 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Bldg. S777			
	18" JP-4 Line			
	Above ground side of insulator	-720	-720	35
	Below ground side of insulator	-775	-820	45
2.	VC-1 & VC-1A			
	16" Avgas Line			
	Protected side of insulator	-800	-890	90
	Unprotected side of insulator	-770	-800	30
3.	VC-12			
	12" Ballast Line	-950	-1010	60
4.	Existing Test Station, E side of Lehua St. & NE of Tank S94			
	Foreign Line Side	-940	-1000	60
	Navy side	-920	-960	40
5.	VC-10			
	10" Mogas to VC-1 & VC-1A	-1010	-1085	75
	10" Mogas to Victor Docks (valve dropped & abandoned)	-525	-515	-10*
	10" Avgas to VC-1 & VC-1A	-985	-1030	45
	10" Avgas to Victor Docks	-985	-1030	45
6.	VC-9			
	14" JP-4 to Victor Docks	-985	-1030	45
7.	Existing Test Station E of Bldg. 724	-1040	-1050	10

8.	VC-4			
	14" JP-4 Tank Farm side of insulator	-930	-945	15
	10" JP-4 to Victor Dock #4	-725	-730	5
9.	Existing Test Station, N of VC-11 with three test leads	-930	-935	5
10.	VC-13			
	All Lines	-1030	-1035	5
11.	VC-B			
	All Lines	-1080	-1085	5

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.


MATCH LINE, OR
DWG. 6494
14" JP-4
16" AVGAS
18" JP-4
12" BALLAST
10" AVGAS
#6
75
108
76
73
72
71
74
#5
788
789
787
790
791
(1965
16" AVGAS)
4
S77
LEHUA
AVE
#3
VC-12
3
5
VC-10
VC-9
#4
6
#1
2
VC-1
1
777
86
S95 #2
S85
VC 3
8
2
1
N
CT #2
RECTIFIER #11 &
ANODE BED
SCALE: NONE
L E G E N D
SOIL RESISTIVITY LOCATION
PIPE-TO-SOIL POTENTIAL LOCATION
CT #1
CURRENT TEST LOCATION
UNDERGROUND POL LINE
LEAK LOCATION
TEST STATION OR TEST BOX
EXISTING ANODE BED
EXISTING RECTIFIER
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA
BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII
CORROSION SURVEY
FIELD DATA
SECTION: A-2
DRAWN: R. E. F
DATE: 2-15-82
APPROVED: H Tso
NUMBER: 6493



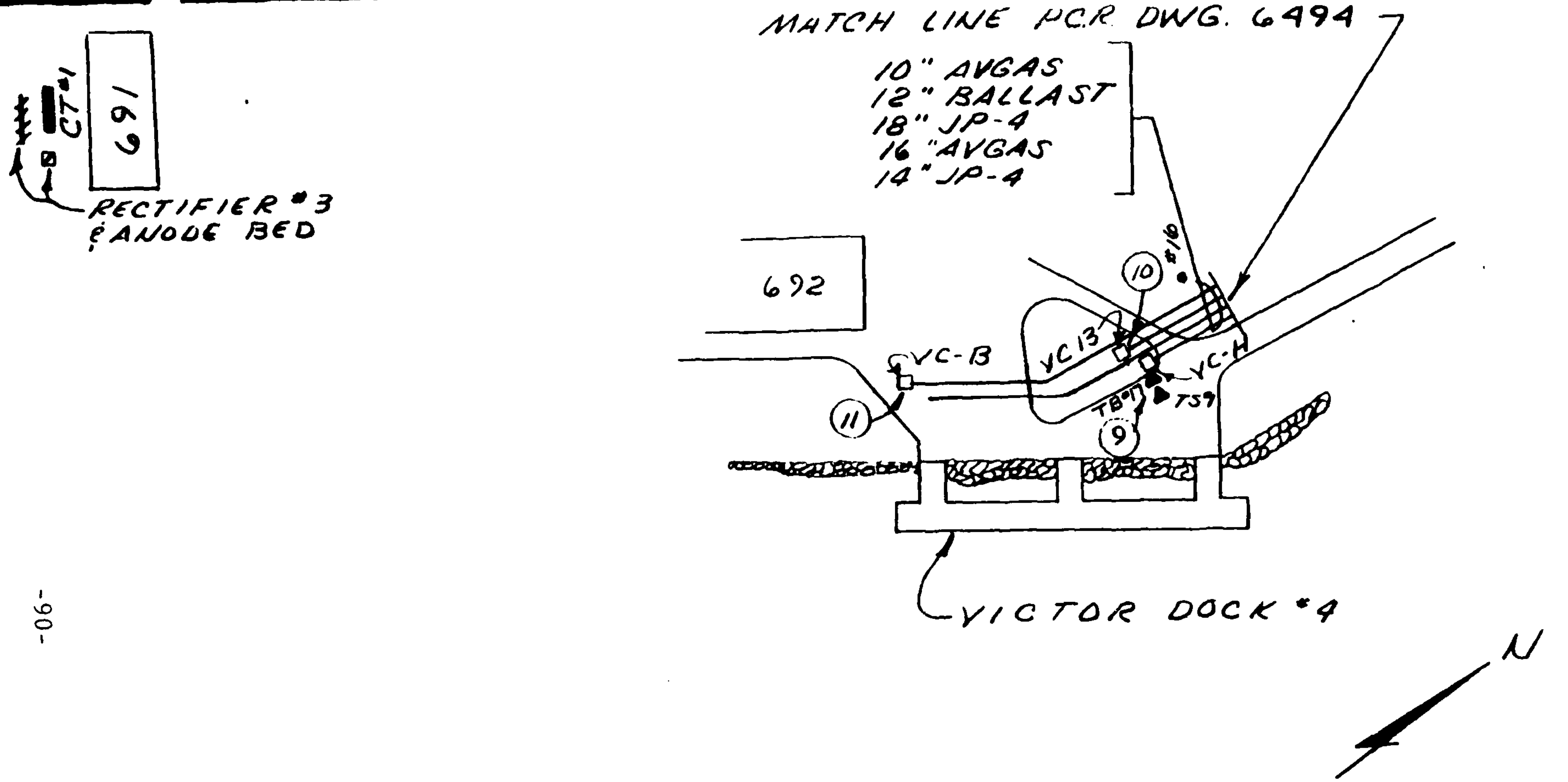
SCALE: NONE

LEGEND

● #1 SOIL RESISTIVITY LOCATION
(1)→ PIPE-TO-SOIL POTENTIAL LOCATION

UNDERGROUND POL LINE
▲ TEST STATION OR TEST BOX

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: A-2
DRAWN: R.E.F.	DATE: 2-15-82
APPROVED: [illegible]	NUMBER: 6494

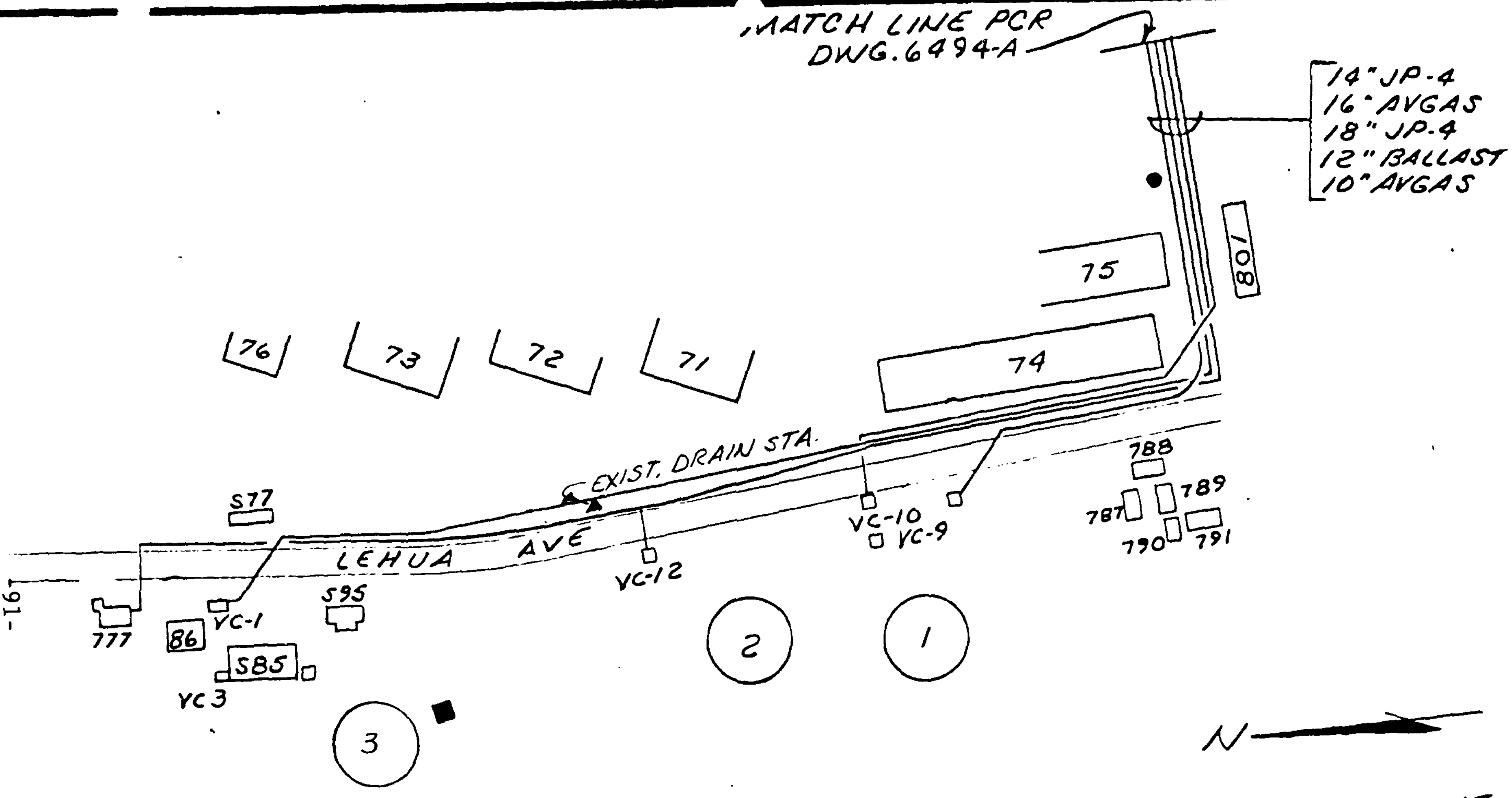


SCALE: NONE

LEGEND

● #1	SOIL RESISTIVITY LOCATION
①	PIPE-TO-SOIL POTENTIAL LOCATION
▬ CT#1	CURRENT TEST LOCATION
───	UNDERGROUND POL LINE
△	LEAK LOCATION
▲	EXISTING TEST STATION OR TEST BOX
☒	EXISTING RECTIFIER
+++	EXISTING ANODE BED

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: A-2
DRAWN: R.E.F.	DATE: 2-15-82
APPROVED: J/ Tso	NUMBER: 6495



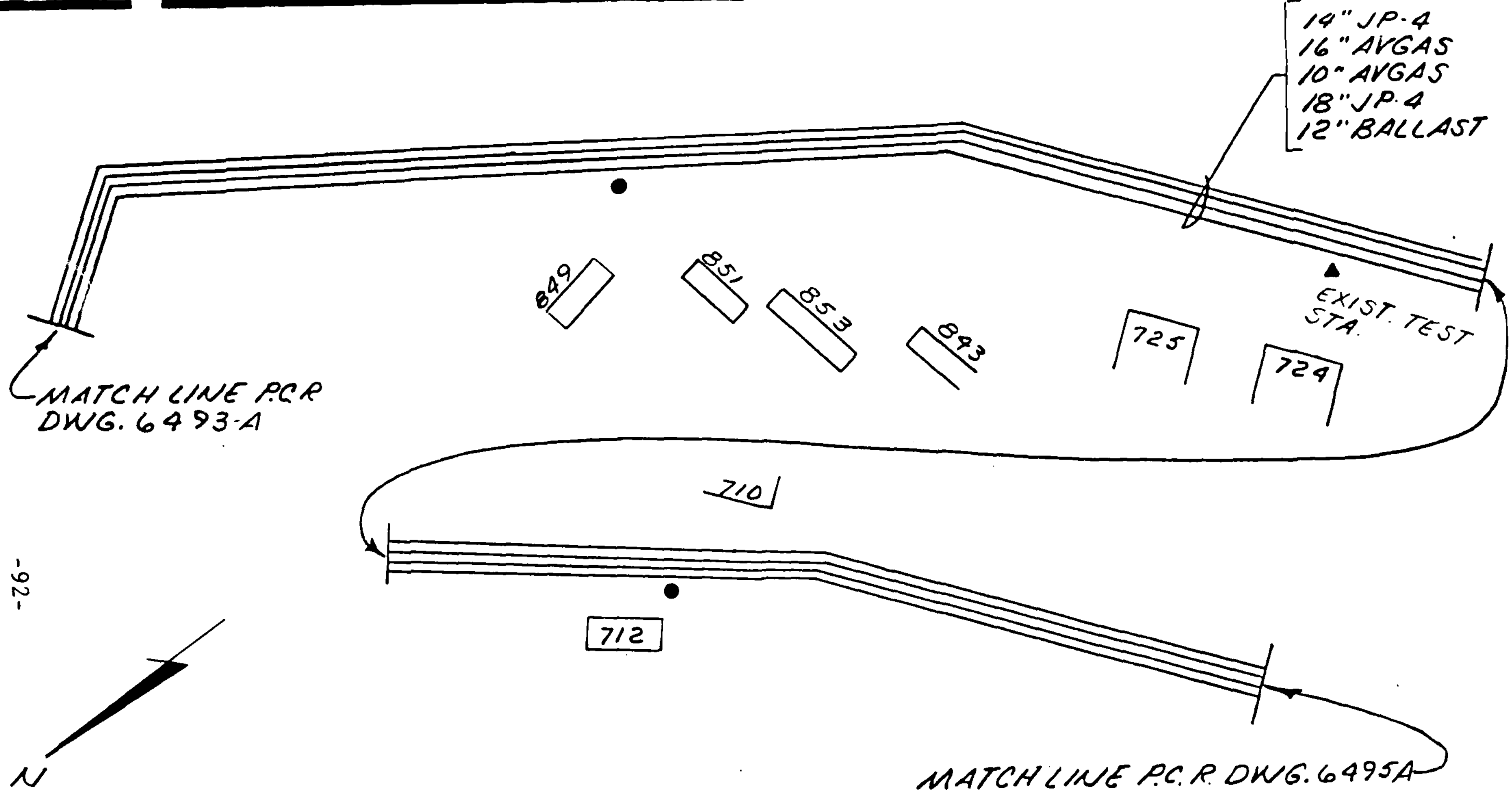
SCALE: NONE

LEGEND

● INSTALL NEW TEST BOX AND INSTALL PREPACKAGED MAGNESIUM ANODES.

■ INSTALL A NEW OIL COOLED RECTIFIER AND INSTALL HIGH SILICON IRON TUBULAR ANODES.

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED C.P. SYS.	SECTION: A-2
DRAWN: R. E. F	DATE: 2-15-82
APPROVED: H. Tso	NUMBER: 6493-A

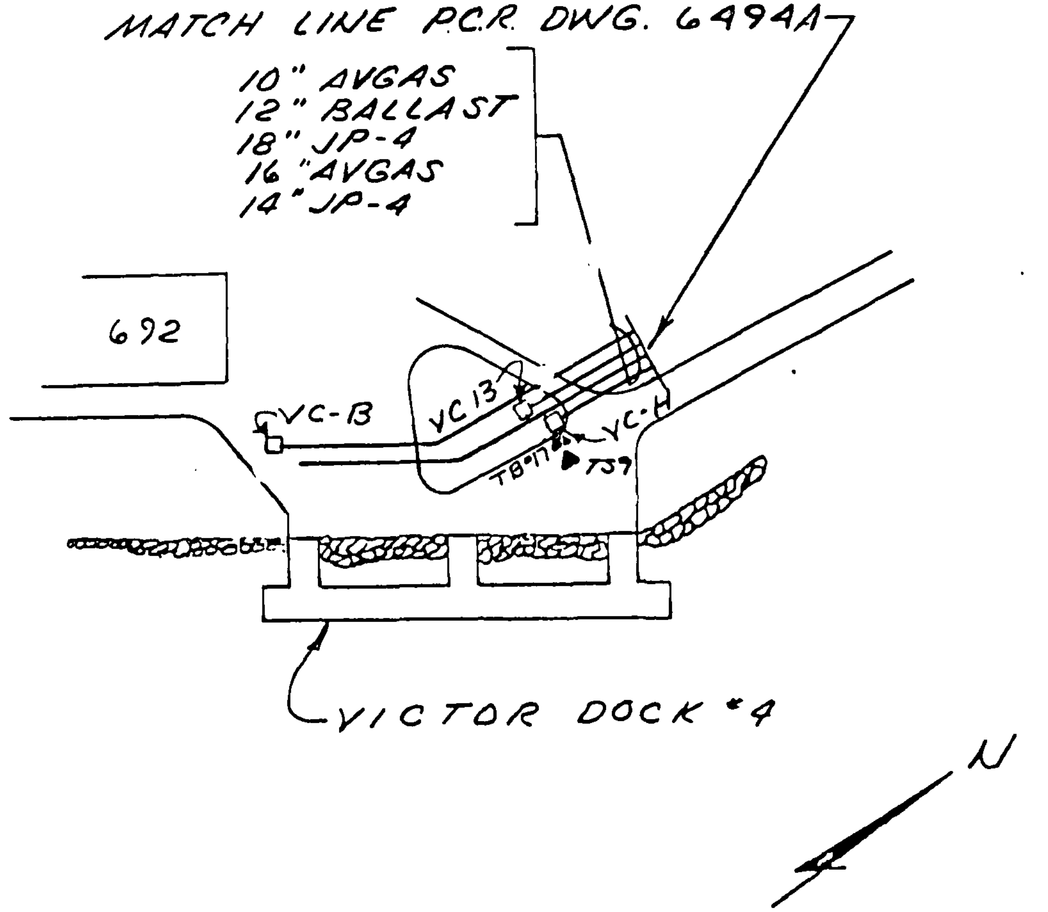


L E G E N D

● INSTALL NEW TEST BOX AND INSTALL PREPACKAGED MAGNESIUM ANODES

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED C.P. SYS.	SECTION: A-2
DRAWN: R.E.F.	DATE: 2-15-82
APPROVED: H.T.S.	NUMBER: 6494-A

169



SCALE: NONE

PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA

BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII

CORROSION SURVEY

PR . SYS.	SECTION: A-2
DRAWN: R.E.F.	DATE: 2-15-82
APPROVED:	NUMBER: 6495-A

SECTION A-3

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX

INCLUDING VICTOR DOCKS AND TWO 10"

AVGAS LINES SERVING HICKHAM A.F.B. FROM VICTOR DOCKS TO THE

CROSSING AT MIDDLE LOCH

SECTION A-3

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX

INCLUDING VICTOR DOCKS AND TWO 10"

AVGAS LINES SERVING HICKHAM A.F.B. FROM VICTOR DOCKS TO THE

CROSSING AT MIDDLE LOCH

SECTION A-3

SUMMARY

1. Conclusions:

Based on the field data obtained, the following conclusions are made:

A. Soil resistivity measurements indicate the environment in Section A-3 can be classified as an area of severe corrosion potential.

B. The POL lines of Section A-3 are at a protective potential level.

C. A total of twenty-two (22) insulators were found to be installed on the POL lines at various locations. Twenty (20) insulators were found to be operating properly. The insulator on the 8" JP-4 line in Northern Valve Pit, Victor Dock #4 and the insulator on the JP-4 line in the Southern Valve Pit, Victor Dock #4 were found to be operating improperly.

D. The POL lines of Section A-3 are electrically continuous with the POL lines of Section A-2, but electrically discontinuous with the cast iron water main in Victor Docks area. Interference was found on the cast iron water main from existing Rectifier #3.

E. Existing Rectifier #3 does provide adequate protection for the underground POL lines of Section A-3.

2. Recommendations:

A. It is recommended that existing anode bed of the existing Rectifier #3 be replaced with ten (10) 4-3/4"x84" high silicon iron tubular anodes. These anodes should be installed 10' below the LLWL on concrete racks (two anodes per rack). Existing Rectifier #3 should be replaced with a new oil cooled rectifier.

B. The two failed insulators on the 8" JP-4 lines in the valve pits of Victor Docks #4 should be replaced.

C. A test box should be installed at VC-H. Two test leads each should be connected to each side of the installed insulator on the JP-4 line and terminated in the test box.

D. To eliminate the interference on the cast iron water main, it will be necessary to install a resistance bond station between the POL lines and the cast iron water main on the south side of Building 691. It is also recommended that the cast iron water main with mechanical joints be bonded across each joint from west of Victor Docks #1 and #2 to north of Victor Docks #3 and #4.

SECTION A-3

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX INCLUDING VICTOR DOCKS AND TWO 10" AVGAS LINES SERVING HICKHAM A.F.B. FROM VICTOR DOCKS TO THE CROSSING AT MIDDLE LOCH.

1. Description.

A. Lines to be Protected:

(1) From VC-H to Victor Dock #4

a. 10" JP-4 Line - Coated Steel

(2) From VC-13 to Victor Dock #4

a. 12" Ballast Line - Coated Steel

b. 16" JP-4 Line - Coated Steel

(3) From VC-J to Victor Dock #4

a. 10" Avgas Line - Coated Steel

(4) From VC-B to Victor Dock #4

a. 10" MP Line - Coated Steel

(5) From VC-B to VC-C

a. 10" Avgas Line - Coated Steel

(6) From VC-13 to VC-14

a. 18" JP-4 Line - Coated Steel

b. 12" Ballast Line - Coated Steel

(7) From West of VC-J to VC-14

a. 12" Avgas Line - Coated Steel

(8) From VC-H to VC-L

a. 14" JP-4 Line - Coated Steel

(9) From VC-14 to Victor Dock #3

a. 12" Ballast Line - Coated Steel

b. 16" JP-4 Line - Coated Steel

(10) From Northeast of VC-14 to Victor Docks #3

a. 10" Avgas Line - Coated Steel

(11) From VC-C to Victor Dock #3

a. 10" Avgas Line - Coated Steel

(12) From VC-K to Victor Dock #3

a. 16" JP-4 Line - Coated Steel

(13) From VC-C to VC-D

a. 8" Avgas Line - Coated Steel

(14) From VC-C to VC-15

a. 8" Ballast Line - Coated Steel

(15) From VC-14 to North of VC-N

a. 12" Avgas Line - Coated Steel

(16) From VC-L to VC-N

a. 14" JP-4 Line - Coated Steel

(17) From VC-D to Victor Dock #2

a. 8" Avgas Line - Coated Steel

(18) From VC-5 to Victor Dock #2

a. 8" Ballast Line - Coated Steel

(19) From VC-M to Victor Dock #2

a. 10" JP-4 Line - Coated Steel

(20) From VC-D to VC-E

a. 8" Avgas Line - Coated Steel

(21) From FC-E to Victor Dock #1

a. 12" Avgas Line - Coated Steel

(22) From Air Force Scraper Launcher to the Crossing at Middle Loch

a. 10" Avgas Line (AF) - Coated Steel

b. 10" JP-4 Line (AF) - Coated Steel

B. Existing Cathodic Protection System:

The POL lines of Section A-3 are cathodically protected by an impressed current and a sacrificial anode cathodic protection system.

(1) Impressed Current C.P. System: This system consists of one 8 volt and 50 ampere oil cooled rectifier and two sections of railroad tracks as anodes.

a. Rectifier Location: Rectifier #3 is located on the South side of Building 691 between Victor Docks #1 and #2.

b. Rectifier Unit: Mfg. - Electrical Facilities, Inc.
Oakland, CA.
Serial No. - 5033571
D.C. Capacity - 8 V, 50 A
Operating at - Tap Setting 5-4
Date Recorded - October 10, 1981

(2) Sacrificial Anode C.P. System: This system consists of three test stations and one sacrificial anode bed.

a. Test Box #17 - Test Box #17 is located on the west side of VC-H with an unknown type and number of anodes. Anode open circuit potentials and current flow measurements were obtained during this survey. The results of these measurements indicate that the anode and/or anodes have deteriorated and exceeded their service life. The results of these measurements are shown in Table No. XXII.

b. Test Station #1 - Test Station #1 is located 7'

west of Test Box #17. Three test leads were found installed from the POL lines and terminated on a 2" diameter galvanized steel post.

c. Test Station #2 - This station is located 6' north of VC-L. Three test leads were found installed from the POL lines and terminated in a 2" diameter galvanized post.

d. Test Station #3 - This test station is located south of 984 Aloha Ave.. Two test leads were found installed on the POL lines and terminated in a concrete test box.

The locations of rectifiers and test stations are shown on PCR Drawings No. 9496 and 9497.

2. Field Work and Evaluation of Data.

a. Soil Resistivity Measurements: A total of six sets of measurements were obtained at representative locations as shown in Table No. III-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	100	Severe
Medium	2,000 - 10,000	0	Moderate
High	10,000 - 30,000	0	Slight unless other factors are pronounced

The low resistivity indicates a severe corrosion condition on underground metallic structures. One hundred percent of the measurements obtained were found to be in the severe category.

B. "As Found" Pipe-to-Soil Potentials: "As found" pipe-to-soil potentials were obtained at each valve chamber and at each test station. The results of these measurements indicate that the POL lines of Section A-3 are at a protective potential level. The results of these measurements are shown in Table No. III-B.

C. Current Tests: One current test was conducted on the POL lines of Section A-3. This current test was conducted as a continuity test. Pipe-to-soil potentials were obtained at the same locations as the "As Found" potentials with existing Rectifier #3 "off" and "on".

The following results were observed from this test:

(1) The POL lines of Section A-3 are electrically continuous with the POL lines of Section A-2.

(2) Existing Rectifier #3 does provide adequate protection for Section A-3.

(3) An insulator was found installed on the POL lines at each of the following locations:

a. 10" JP-4 Line in VC-H - Functioning properly

b. 8" MP Line in Northern Valve Pit, Victor Dock #4 - Functioning properly

c. 8" Avgas Line in Northern Valve Pit, Victor Dock #4 - Functioning properly

d.	10" JP-4 Line in Northern Valve Pit, Victor Dock #4	- Functioning properly
e.	8" JP-4 Line in Northern Valve Pit, Victor Dock #4	- Functioning improperly
f.	8" JP-4 Line in Southern Valve Pit, Victor Dock #4	- Functioning improperly
g.	10" JP-4 Line in Southern Valve Pit, Victor Dock #4	- Functioning properly
h.	8" MP Line in Southern Valve Pit, Victor Dock #4	- Functioning properly
i.	8" Avgas Line in Southern Valve Pit, Victor Dock #4	- Functioning properly
j.	8" MP Line in Southern Valve Pit, Victor Dock #4	- Functioning properly
k.	8" MP Line in Northern Valve Pit, Victor Dock #4	- Functioning properly
l.	8" Avgas Line in Northern Valve Pit, Victor Dock #4	- Functioning properly
m.	8" MP Line in Northern Valve Pit, Victor Dock #4	- Functioning properly
n.	10" JP-4 Line in Northern Valve Pit, Victor Dock #4	- Functioning properly
o.	8" JP-4 Line in Northern Valve Pit, Victor Dock #4	- Functioning properly
p.	8" JP-4 Line in Southern Valve Pit, Victor Dock #3	- Functioning properly
q.	10" JP-4 Line in Southern Valve Pit, Victor Dock #3	- Functioning properly

r. 8" Ballast Line in Southern Valve Pit, Victor Dock #3 - Functioning properly

s. 8" Avgas Line in Southern Valve Pit, Victor Dock #3 - Functioning properly

t. 8" MP Line in Southern Valve Pit, Victor Dock #3 - Functioning properly

u. 10" Avgas line at the Air Force Scraper Launcher - Bond across insulator

v. 10" JP-4 line at the Air Force Scraper Launcher - Bond across insulator

(4) The cast iron water main north of Victor Docks #1 and #2 and west of Victor Docks #3 and #4 are not electrically continuous with the POL lines. Interference was found on the cast iron water main from existing Rectifier #3.

D. Inspection of Pipelines: Inspection of the POL lines under Victor Docks were made on October 11, 1981. The POL lines under the Victor Docks are supported by galvanized steel hangers. It was found that the coating of the POL lines, in contact with the hangers, at various locations had been damaged by the hangers. Generally, the coating in the other areas was found to be in fair condition.

E. Leak History: The leak history was discussed with Mr. John Kimi, Mr. Albert Wong and personnel of the Pearl City Tank Farm. Numerous leaks on the "A" and "B" lines have been found since 1958. We were advised that the "A" and "B" lines from VC-9 and VC-10 to Victor Docks were abandoned due to leaks. The leaks on the POL lines of Section A-3

are shown in PCR Drawings No. 9496 and 9497.

3. <u>Conclusions</u>.

Based on the field data obtained, the following conclusions are made:

A. Soil resistivity measurements indicate that 100% of the readings are in the severe category. The environment in Section A-3 can be classifed as an area of severe corrosion potential.

B. The POL lines of Section A-3 are at a protection potential level.

C. A total of 22 insulators were found to be installed on the POL lines at various locations. Each insulator was checked during this survey. Twenty insulators were found to be operating properly. The insulator on the 8" JP-4 line in Northern Valve Pit, Victor Dock #4 and the insulator on the 8" JP-4 line in the Southern Valve Pit, Victor Dock #4 were found to be operating improperly.

D. The POL lines of Section A-3 are electrically continuous with the POL lines of Section A-2.

E. Existing Rectifier #3 does provide adequate protection for the underground POL lines of Section A-3.

F. The cast iron water main in Victor Docks area is not electrically continuous with the POL lines. The cast iron water main was also found to be electrically continuous from section to section in the line. Interference was found on the cast iron water main from existing Rectifier #3.

G. Inspection of the POL lines under the Victor Docks indicate

that the coating of the POL lines is in fair condition with the exception of the areas where the POL lines are in contact with the hangers, the coating has been damaged by the hangers.

4. Recommendations.

A. From the results of the field data obtained, it is recommended that existing anode bed consisting of two sections of railroad tracks of existing Rectifier #3 be replaced with ten 4 3/4" x 84" high silicon iron tubular anodes. These anodes should be installed 10' below the LLWL on concrete racks (two anodes per rack). The five concrete racks with anodes should be positioned on the sea floor with the anodes placed in a direction normal to the POL lines. Existing Rectifier #3 should be replaced with a new oil cooled rectifier.

B. The two failed insulators on the 8" JP-4 lines in the valve pits of Victor Docks #4 should be replaced.

C. A test box should be installed at VC-H. Two test leads each should be connected to each side of the installed insulator on the JP-4 line and terminated in the test box.

D. To eliminate the interference on the cast iron water main, it will be necessary to install a resistance bond station between the POL lines and the cast iron water main on the south side of Building 691. It is also recommended that the cast iron water main with mechanical joints be bonded across each joint from west of Victor Docks #1 and #2 to north of Victor Docks #3 and #4.

E. It is recommended that the damaged coating areas of the POL lines under Victor Docks be repaired by recoating the line in the damaged areas with a polymastic, by the glove method. It is also recommended that a 4" wide semi-circular PVC sleeve be placed at each location between each hangar and the POL lines.

F. The two Air Foces POL lines from Air Force Scraper Launcher to the crossing at Middle Loch are maintained by the Navy NSC, Fuel Department. These two lines were found to be cathodically protected at the time of this survey.

It is recommended that a resistance bond station be installed at the existing insulator between the Navy owned POL line and the Air Force lines at the Air Force Scraper Launcher.

NOTE: The locations of the pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawings No. 6496 and 6497.

The recommended C.P. systems of Section A-3 are shown on PCR Drawings No. 6496-A and 6497-A.

NAVFAC 11013/7 (1 78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION A-3

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
4 3/4"x84" HI SILICON IRON TUBULAR ANODES	10	ea	720.00	7200.00	225.00	2250.00	945.00	9450.00
CONCRETE RACKS	5	ea	975.00	4875.00	750.00	3750.00	1725.00	8625.00
OIL COOLED RECTIFIERS	1	ea	1950.00	1950.00	600.00	600.00	2550.00	2550.00
INSULATING FLANGE SET	2	ea	45.00	90.00	75.00	150.00	120.00	240.00
1" PVC CLASS 200, PLASTIC PIPE	100	ft	0.75	75.00	0.15	15.00	0.90	90.00
RESISTANCE BOND STATION	1	ea	150.00	150.00	150.00	150.00	300.00	300.00
#2 HMP STRANDED COPPER CABLE	200	ft	1.50	300.00	0.15	30.00	1.65	330.00
CONCRETE PAD	1	ea	150.00	150.00	600.00	600.00	750.00	750.00
SPLIT BOLTS	15	ea	1.05	15.75	4.50	67.50	5.55	83.25
CONCRETE TEST BOXES/CAST IRON LIDS	2	ea	45.00	90.00	75.00	150.00	120.00	240.00
COAL TAR ENAMEL (1 GALLON CAN)	1	ea	22.50	22.50	45.00	45.00	67.50	67.50
BUTYL TAPE	2	rl	37.50	75.00	45.00	90.00	82.50	165.00
RUBBER TAPE	6	rl	4.50	27.00	7.50	45.00	12.00	72.00
PLASTIC TAPE	6	rl	4.50	27.00	7.50	45.00	12.00	72.00
TERRA TAPE	100	ft	0.22	22.00	0.08	8.00	0.30	30.00
ALUMINO-THERMIC WELDS	8	ea	3.00	24.00	37.50	300.00	40.50	324.00
TRENCH	60	ft	--	--	7.50	450.00	7.50	450.00

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

NAVFAC 11013/7 (1 78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 2 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION A-3

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
BONDING OF CAST IRON PIPE	2000	ft	3.00	6000.00	10.50	21000.00	13.50	27000.00
SUBTOTAL				21093.25		29745.50		50838.75
10% MISC. MATERIALS & LABOR				2109.00		2974.00		5083.00
SUBTOTAL				23202.25		32719.50		55921.75
30% CONSTRUCTION PROFIT				6960.67		9815.85		16776.52
TOTAL				30162.92		42535.35		72698.27

S/N 0105-LF-010-1335
★ G.P.([illegible] 689-016/4302

SECTION A-3

SOIL RESISTIVITIES

TABLE NO. III-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	100' W of Victor Dock #4	1300	380	360
2.	60' W of Victor Dock #3	1000	400	240
3.	40' N of Victor Dock #2	1400	320	240
4.	200' E of Victor Dock #1, near Rectifier #3	1200	380	480
5.	140' N of VC-'N'	1300	640	520
6.	40' SW of 984 Aloha St.	700	200	200

SECTION A-3

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. III-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	VC-H	
	14" JP-4 to P.C. Tank Farm	- 930
	14" JP-4 to Victor Docks	- 930
	10" JP-4 to Victor Dock #4	- 725
2.	Existing Test Station N of VC-H	- 930
3.	VC-13	
	All Lines	-1030
4.	VC-B	
	All Lines	-1080
5.	VC-J	
	Line to N	-1020
	Line to S (valve dropped & abandoned)	- 565
6.	Victor Dock #4	
	Northern Pit	
	8" Multi-Product Line	
	Pier side of Insulator	- 740
	Underground side of Insulator	-1050
	8" Avgas Line	
	Pier side of Insulator	- 740
	Underground side of Insulator	-1050
	8" Multi-Product Line	
	Pier side of Insulator	- 740
	Underground side of Insulator	-1050
	10" JP-4 Line	
	Pier side of Insulator	- 740
	Underground side of Insulator	-1050
	8" JP-4	
	Pier side of Insulator	- 740
	Underground side of Insulator	- 740
	Southern Pit	
	8" JP-4 Line	
	Pier side of Insulator	- 740
	Underground side of Insulator	- 740
	10" JP-4 Line	
	Pier side of Insulator	- 740
	Underground side of Insulator	-1050
	8" Product Line	
	Pier side of Insulator	- 740
	Underground side of Insulator	-1050

	8" Avgas Line	
	Pier side of Insulator	- 740
	Underground side of Insulator	-1050
	8" Multi-Product Line	
	Pier side of Insulator	- 740
	Underground side of Insulator	-1050
7.	VC-14	
	All Lines	-1110
8.	VC-K	
	12" JP-4 to Victor Dock #3	-1050
	12" JP-4 to N	- 960
9.	VC-F	
	10" Mogas (Abandoned)	- 660
	10" Avgas (Abandoned)	- 660
	8" Water Line	- 660
10.	VC-C	
	All Lines	-1130
11.	Victor Dock #3	
	Northern Pit	
	8" Multi-Product Line	
	Pier side of Insulator	-1120
	Underground side of Insulator	-1120
	8" Avgas Line	
	Pier side of Insulator	-1120
	Underground side of Insulator	-1120
	8" Ballast Line	
	Pier side of Insulator	-1120
	Underground side of Insulator	-1120
	10" JP-4 Line	
	Pier side of Insulator	-1120
	Underground side of Insulator	-1120
	8" JP-4 Line	
	Pier side of Insulator	-1120
	Underground side of Insulator	-1120
	Southern Pit	
	8" JP-4 Line	
	Pier side of Insulator	-1140
	Underground side of Insulator	-1140
	10" JP-4 Line	
	Pier side of Insulator	-1140
	Underground side of Insulator	-1140
	8" Ballast Line	
	Pier side of Insulator	-1140
	Underground side of Insulator	-1140
	8" Avgas Line	
	Pier side of Insulator	-1140
	Underground side of Insulator	-1140
	8" Multi-Product Line	
	Pier side of Insulator	-1140
	Underground side of Insulator	-1140

12.	Existing test station with three test leads near VC-L	-1020
13.	VC-L	
	10" JP-4 to SE (abandoned)	- 600
	14" JP-4 Line	-1010
14.	VC-D	
	All Lines	-1240
15.	VC-15	
	All Lines	-1200
16.	VC-M	
	12" JP-4 line to N	-1070
	12" JP-4 line to Pier	-1140
17.	VC-2	
	10" Avgas Line to Pier	- 910
	10" Avgas Line to N	-1080
18.	VC-1	
	10" Avgas line to N	-1050
	10" Avgas Line to Pier	-1010
19.	VC-E	
	8" Avgas line to E	-1230
	8" Avgas Line to Pier	-1050
20.	VC-N	
	12" JP-4 line to E	-1050
	12" JP-4 line to W	- 910
21.	VC-5 (abandoned)	
	10" Line to E	-1050
	10" Line to S	- 650
22.	10" Avgas Line (Air Force)	
	Navy side of Insulator	- 990
	Air Force side of Insulator	- 990
23.	10" JP-4 Line (Air Force)	
	Navy side of Insulator	- 990
	Air Force of Insulator	- 990
24.	Existing Test Station with two test leads SW of 986 Aloha Avenue	-1030

SECTION A-3

CURRENT TEST NO. 1

TABLE NO. III-C

Location:	Existing Rectifier #3, south of Bldg. 691 between Victor Dock #1 & #2.
Number of Anodes used for Current Test:	Three sections of railroad track installed approximately 30' off the shore line on the ocean floor.
Negative Connection:	Existing.
Rectifier D.C. Output:	3.5 volts - 13 amperes D.C.

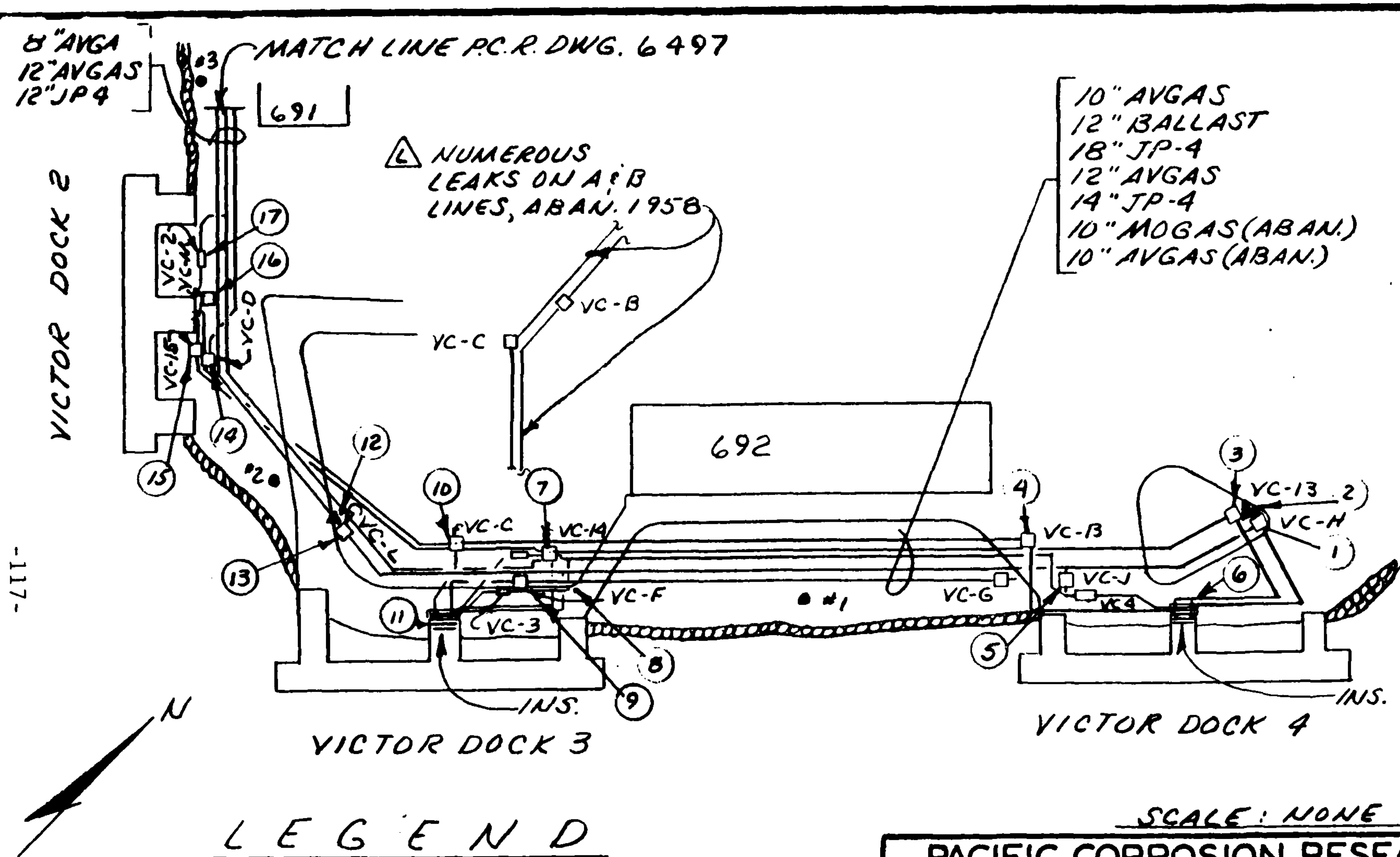
Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC-H			
	14" JP-4 Line to P.C. Tank Farm	-880	-930	50
	14" JP-4 Line to Victor Docks	-880	-930	50
	10" JP-4 Line to Victor Dock #4	-710	-725	15
2.	Existing Test Station N of VC-H	-880	-930	50
3.	VC-13			
	All Lines	-930	-1030	100
4.	VC-B			
	All Lines	-970	-1080	110
5.	VC-J			
	Line to N	-920	-1020	100
	Line to S (valve dropped & abandoned)	-570	-565	-5*
6.	Victor Dock #4			
	Northern Pit			
	8" Multi-Product Line			
	Pier side of Ins.	-730	-740	10
	Underground side of Ins.	=950	-1050	100
	8" Avgas Line			
	Pier side of Ins.	-730	-740	10
	Underground side of Ins.	-950	-1050	100

	8" Multi-Product Line			
	Pier side of Ins.	-730	-740	10
	Underground side of Ins.	-950	-1050	100
	10" JP-4 Line			
	Pier side of Ins.	-730	-740	10
	Underground side of Ins.	-950	-1050	100
	8" JP-4 Line			
	Pier side of Ins.	-730	-740	10
	Underground side of Ins.	-730	-740	10
	Southern Pit			
	8" JP-4 Line			
	Pier side of Ins.	-720	-740	20
	Underground side of Ins.	-720	-740	20
	10" JP-4 Line			
	Pier side of Ins.	-720	-740	20
	Underground side of Ins.	-950	-1050	100
	8" Multi-Product Line			
	Pier side of Ins.	-720	-740	20
	Underground side of Ins.	-950	-1050	100
	8" Avgas Line			
	Pier side of Ins.	-720	-740	20
	Underground side of Ins.	-950	-1050	100
	8" Multi-Product Line			
	Pier side of Ins.	-720	-740	20
	Underground side of Ins.	-950	-1050	100
7.	VC-14			
	All Lines	-930	-1110	180
8.	VC-K			
	12" JP-4 to Victor Dock #3	-950	-1050	100
	12" JP-4 to N	-950	-960	10
9.	VC-F			
	10" Mogas (abandoned)	-640	-660	20
	10" Avgas (abandoned)	-640	-660	20
	8" Water Line	-630	-660	30
10.	VC-C			
	All Lines	-930	-1130	200
11.	Victor Dock #3			
	Northern Pit			
	8" Multi-Product Line			
	Pier side of Ins.	-990	-1120	130
	Underground side of Ins.	-990	-1120	130

	8" Avgas Line			
	Pier side of Ins.	-990	-1120	130
	Underground side of Ins.	-990	-1120	130
	8" Ballast Line			
	Pier side of Ins.	-990	-1120	130
	Underground side of Ins.	-990	-1120	130
	10" JP-4 Line			
	Pier side of Ins.	-990	-1120	130
	Underground side of Ins.	-990	-1120	130
	8" JP-4 Line			
	Pier side of Ins.	-990	-1120	130
	Underground side of Ins.	-990	-1120	130
	Southern Pit			
	8" JP-4 Line			
	Pier side of Ins.	-950	-1140	190
	Underground side of Ins.	950	-1140	190
	10" JP-4 Line			
	Pier side of Ins.	-950	-1140	190
	Underground side of Ins.	-950	-1140	190
	8" Ballast Line			
	Pier side of Ins.	-950	-1140	190
	Underground side of Ins.	-950	-1140	190
	8" Avgas Line			
	Pier side of Ins.	-950	-1140	190
	Underground side of Ins.	-950	-1140	190
	8" Multi-Product Line			
	Pier side of Ins.	-950	-1140	190
	Underground side of Ins.	-950	-1140	190
12.	Existing test station with three test leads near VC-L	-900	-1020	120
13.	VC-L			
	10" JP-4 to SE (abandoned)	-600	-600	0
	14" JP-4 Line	-900	-1010	110
14.	VC-D			
	All Lines	-1020	-1240	220
15.	VC-15			
	All Lines	-1000	-1200	200
16.	VC-M			
	12" JP-4 Line to N	-970	-1070	100
	12" JP-4 Line to Pier	-990	-1140	150

17.	VC-2			
	10" Avgas Line to Pier	-815	-910	95
	10" Avgas Line to N	-970	-1080	110
18.	VC-1			
	10" Avgas Line to N	-990	-1050	60
	10" Avgas Line to Pier	-900	-1010	110
19.	VC-E			
	8" Avgas line to E	-1030	-1230	200
	8" Avgas line to Pier	-890	-1050	160
20.	VC-N			
	12" JP-4 line to E	-930	-1050	120
	12" JP-4 line to W	-820	-910	90
21.	VC-5 (abandoned)			
	10" Line to E	-890	-1050	160
	10" Line to S	-550	-650	100
22.	10" Avgas Line (Air Force)			
	Navy side of Ins.	-990	-990	0
	Air Force side of Ins.	-990	-990	0
23.	10" JP-4 Line (Air Force)			
	Navy side of Ins.	-990	-990	0
	Air Force side of Ins.	-990	-990	0
24.	Existing Test Station with two test leads SW of 986 Aloha Ave.	-970	-1030	60

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

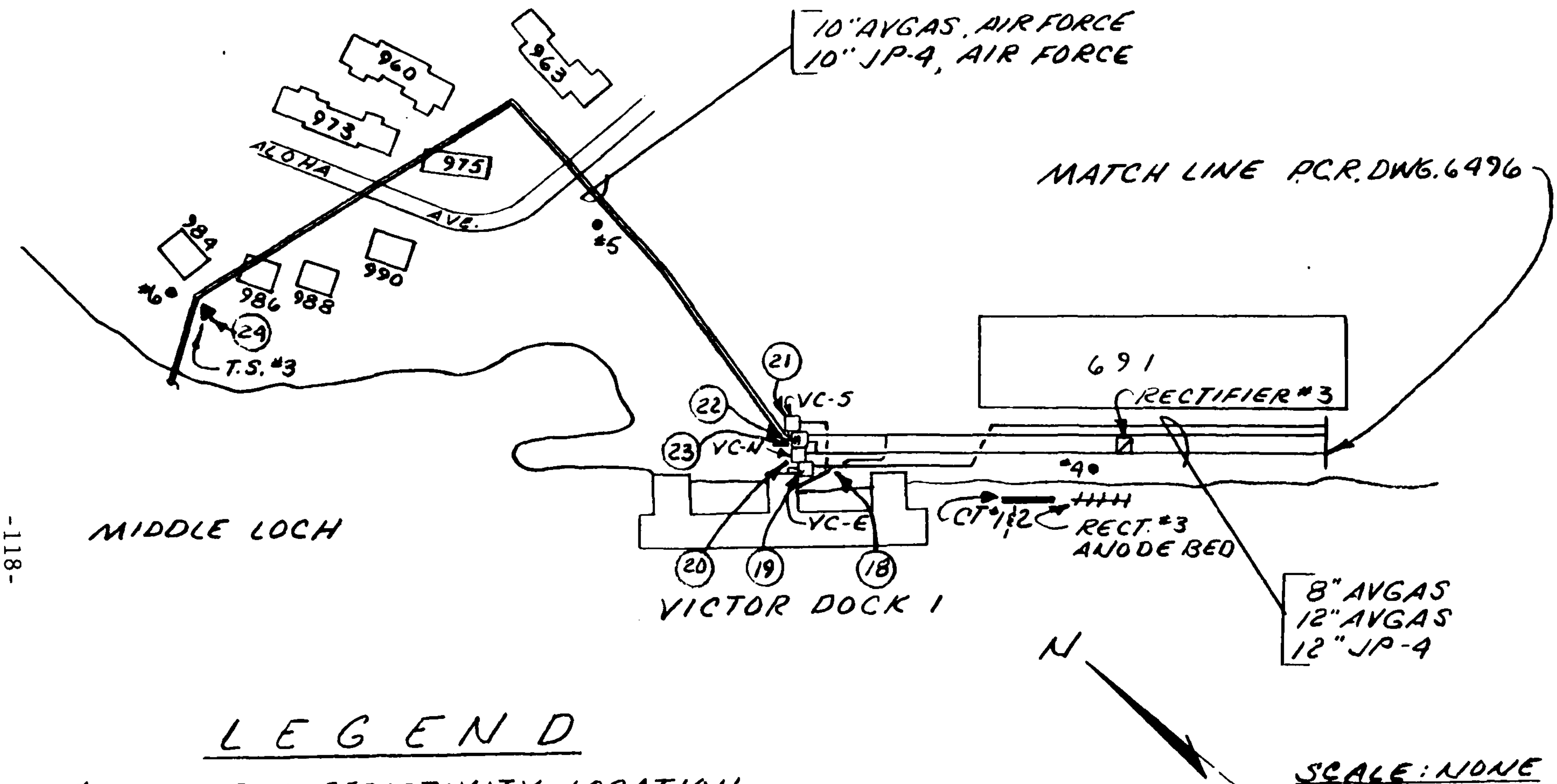


LEGEND

- SOIL RESISTIVITY LOCATION
- PIPE-TO-SOIL POTENTIAL LOCATION
- UNDERGROUND POL LINE
- EXISTING TEST STATION OR TEST BOX
- INS. INSULATING FLANGE
- LEAK LOCATION, POL LINE

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: A-3
DRAWN: R.E.F.	DATE: 2-15-82
APPROVED: H.T.S.	NUMBER: 6496

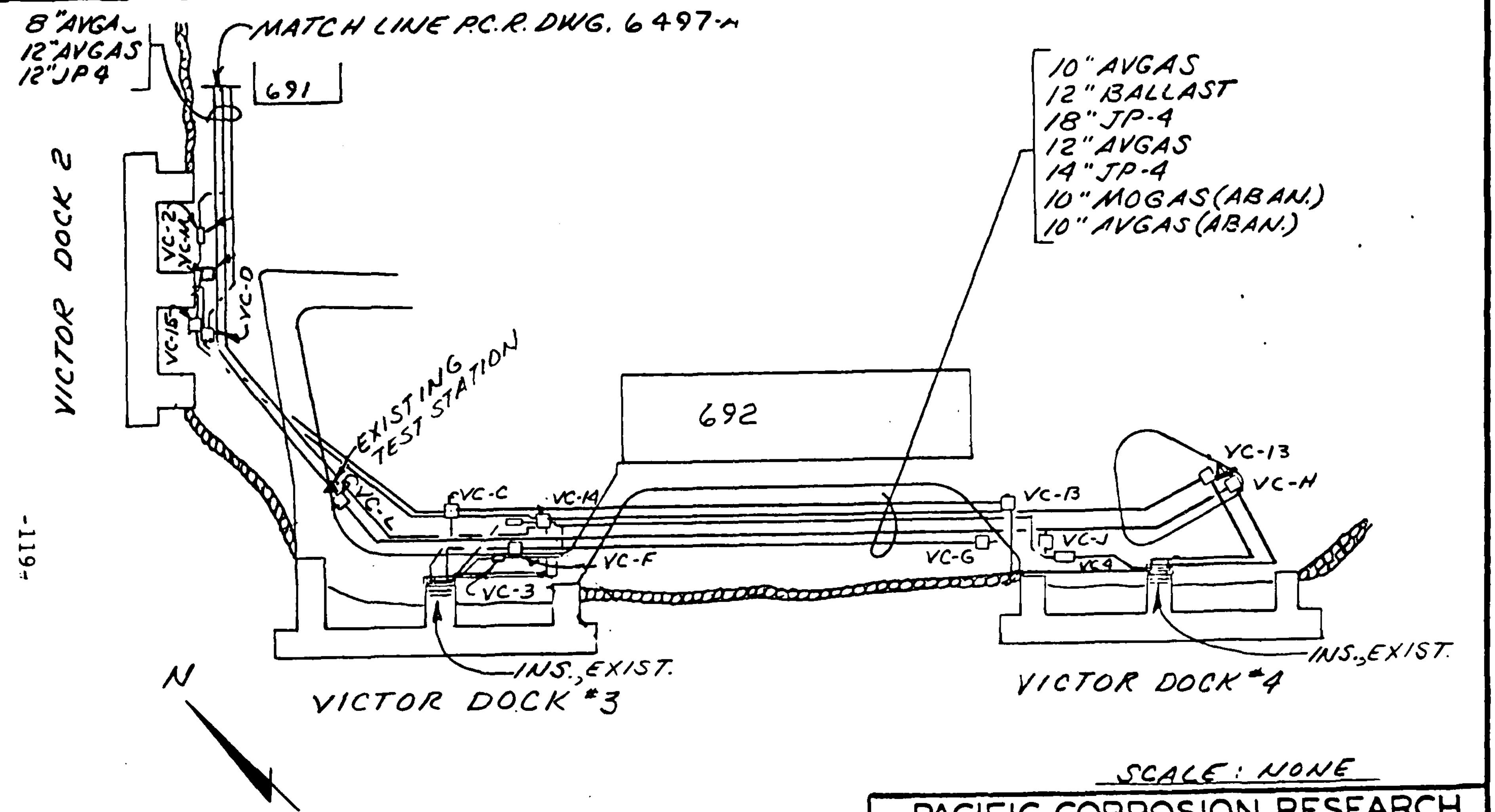


LEGEND

- #1 — SOIL RESISTIVITY LOCATION
- (1) — PIPE-TO-SOIL POTENTIAL LOCATION
- CT #1 & 2 — CURRENT TEST LOCATION
- INSULATING FLANGE
- UNDERGROUND POL LINE
- EXISTING TEST STATION OR TEST BOX
- EXISTING RECTIFIER
- EXISTING ANODE BED

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: A-3
DRAWN: R.E.F.	DATE: 2-15-82
APPROVED: H Tso	NUMBER: 6497

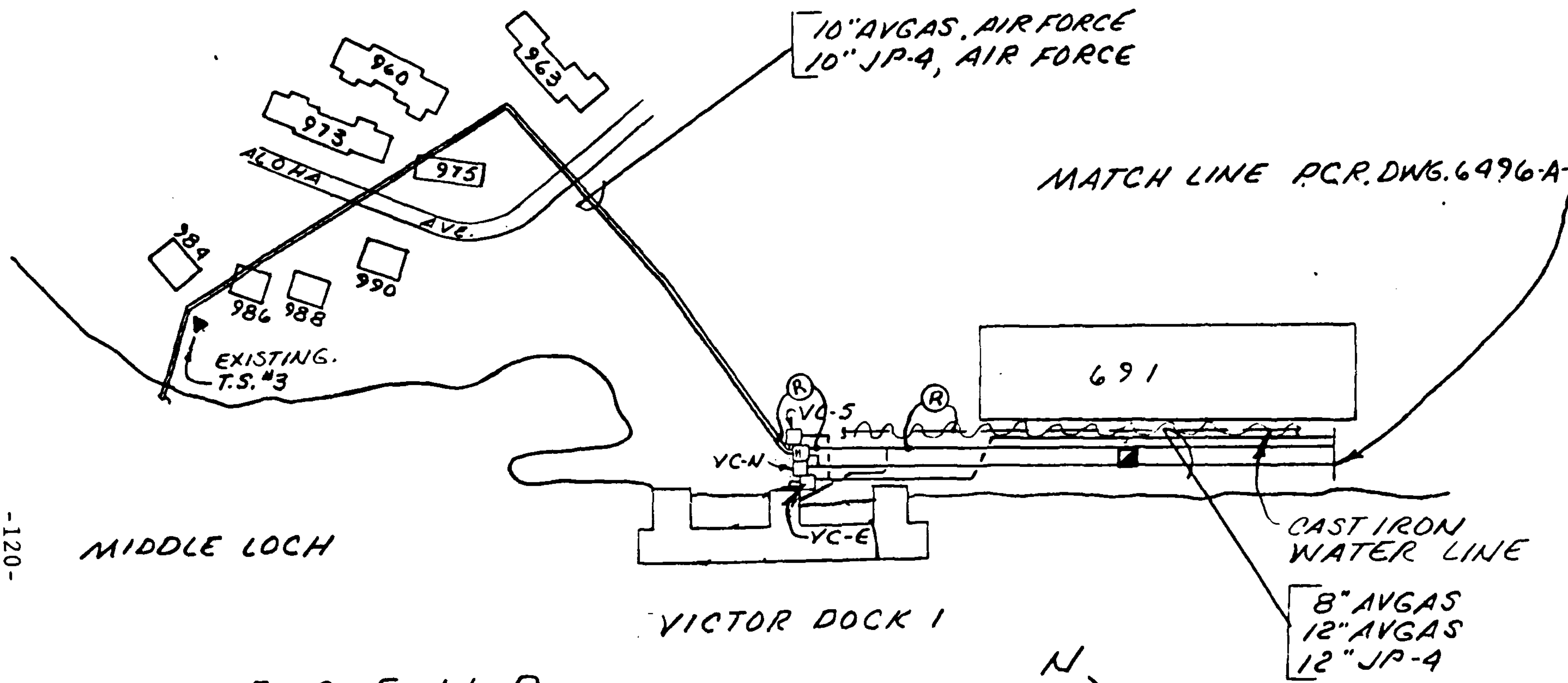


SCALE: NONE

LEGEND

—||— REPLACE EXISTING INSULATORS WITH NEW INSULATOR AT VICTOR DOCKS #3 & 4

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED CP SYS.	SECTION: A-3
DRAWN: R.E.F.	DATE: 2-15-82
APPROVED: A.T.Jr.	NUMBER: 6496-A



LEGEND

CONTINUITY BOND ACROSS EACH JOINT OF CAST IRON WATER LINE

INSTALL RESISTANCE BOND STATION

REPLACE EXISTING RECTIFIER #3 WITH A NEW OIL COOLED RECTIFIER AND INSTALL HIGH SILICON IRON TUBULAR ANODES

SCALE: NONE

PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA

BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII

CORROSION SURVEY

PROPOSED C.P. SYS.	SECTION: A-3
DRAWN: R.E.F.	DATE: 2-15-82
APPROVED: H Tso	NUMBER: 6497-A

SECTION A-4

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE 8" JP-5 LINE SERVING

N.A.S., BARBERS POINT FROM PEARL CITY TANK FARM

SECTION A-4

SECTION A-4

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE 8" JP-5 LINE SERVING

N.A.S., BARBERS POINT FROM PEARL CITY TANK FARM

SECTION A-4

SUMMARY

1. Conclusions:

Based on the field data obtained, the following results were observed:

A. The soil environment of Section A-4 can be classified as an area of having severe corrosive potential.

B. The 8" JP-5 line of Section A-4 is not at a protective potential level.

C. The existing anode bed of Rectifier #5 was not installed within the easement of the 8" JP-5 line and/or on the Government property. During this survey, the anode header cable was found badly damaged by construction work to clear debris out of the stream.

D. Approximately 95,330 sq. ft. of coated steel POL lines are to be considered for cathodic protection. Approximately 80 amperes D.C. will be required to provide a protective potential level for this line.

2. Recommendations:

A. The existing damaged anode bed of Rectifier #5 should be replaced with ten (10) 4"x40" graphite anodes. These anodes should be installed within the easement of the 8"JP-5 line. The existing rectifier should be replaced with a new oil cooled rectifier. This anode bed will provide partial protective current for the NAS, Barbers Point.

B. The results of current tests indicate an additional impressed current anode bed and fourteen (14) additional sacrificial anode beds will be required in future design.

(1) Impressed Current Anode Bed
This anode bed will consist of twelve (12) 4½"x60" high silicon iron anodes and one oil cooled rectifier. These should be installed in the area adjacent to VC-5.

(2) Sacrificial Anode Bed

A total of fourteen (14) new anode beds should be installed at the following locations. Each anode bed will consist of one test box, five (5) 50 lb. prepackaged magnesium anodes and an anode watering system, in the U,S.M.C., West Loch Ammunition Depot.

a. One anode bed should be installed in the area adjacent to VC-3.

b. Five anode beds should be installed north of VC-3 on the west side of Waipio Point Access Road.

c. Five anode beds should be installed between the Waiawa Stream and VC-1.

d. Three anode beds should be installed east of the Waipio Stream.

C. An insulating flange and a resistance bond station should be installed at each of the following locations:

(1) VC-5, Pearl City Tank Farm.

(2) VC-1, NAS, Barbers Point Fuel Tank Farm.

D. A resistance bond station should be installed between the Navy owned 8" JP-5 line and the Standard Oil Company fuel lines at each of the following locations:

(1) West of Waipoi Stream.

(2) Near VC-1.

F. During this survey, PCR was requested by Mr. Jim Gammon, Superintendent of the Fuel Department, N.S.C., to study and redesign a cathodic protection system for the proposed relocated 8" JP-5 line. The design was completed after additional field data had been obtained in October of 1981. The technical plans, specifications and calculations were submitted to Mr. Jim Gammon, on October 30, 1981. It is recommended that the cathodic protection system for the proposed relocated 8" JP-5 line be installed as designed.

SECTION A-4

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX INCLUDING THE 8" JP-5 LINE SERVING N.A.S., BARBERS POINT FROM PEARL CITY TANK FARM

1. Description.

A. Lines to be protected:

(1) From VC-5, Pearl City Tank Farm to Barbers Point

8" JP-5 line - Coated Steel

B. Existing Cathodic Protection System:

This 8" JP-5 line, from VC-5 at Pearl City Tank Farm to Barbers Point was originally designed to be protected by one oil cooled rectifier (#5) and its anode bed. This rectifier was found not in operation at the time of this survey. The anode bed was installed 500' and perpendicular to the 8" JP-5 line. The underground anode header cable, on the east side of the stream, was found to be torn out recently by construction work that was done in order to clear out the debris from the stream.

a. Rectifier Location: Rectifier #5 is located on south side of the bridge near Gate #3, NAS, Barbers Point.

b. Rectifier Unit: Mfg. - Electrical Facilities, Inc.
Serial No. - Unknown (No name plate)
D.C. Capacity - 50 V, 50 A
Operating at - Tap setting 2-7
D.C. Output - 42 V, 0 A
Date Recorded - December 5, 1981

2. Field Work and Evaluation of Data.

A. Soil Resistivity Measurements: A total of 41 sets of mea-

surements were obtained at representative locations as shown in Table No. IV-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	43	Severe
Medium	2,000 - 10,000	47	Moderate
High	10,000 - 30,000	8	Slight unless other factors are pronounced
Very High	Above - 30,000	2	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on underground metallic structures. Forty-three percent of the measurements obtained were in the severe category and forty-seven percent were in the medium or moderate category.

B. "As Found" Pipe-to-Soil Potentials: "As Found" pipe-to-soil potentials were obtained at each valve chamber and at each contact point. The results of these measurements indicate that the 8" JP-5 lines are not at a protective potential level. The three Standard Oil Company fueld lines which run parallel to the Navy owned 8" JP-5 line, from Waiawa Stream to Waipio Point Access Road, are cathodically protected by Standard Oil Company. The results of these measurements are shown in Table No. IV-B in the appendix of

this report.

C. Current Tests: Five current tests were conducted on this section of POL lines. Pipe-to-soil potentials were obtained at representative locations with the test rectifier "off" and "on".

(1) Current Test No. 1 - This current test was conducted in the area adjacent to Pearl City Tank Farm as a continuity test. Pipe-to-soil potentials were obtained at representative locations of Section A-4. Pipe-to-soil potentials were obtained while the existing Rectifier #11 was turned "off" and "on". The results of this current test are shown in Table No. IV-C.

(2) Current Test No. 2 - This current test was conducted in the area south of Valve Chamber #1. A junk car six feet off the shore line was used as a test anode bed. The negative and positive wire from a test rectifier was connected to the POL line in the Valve Chamber #1 and the junk car respectively. The current used for this test was 27 amperes D.C.. The results of this test are in Table No. IV-D in the appendix of this report.

(3) Current Test No. 3 - This test was conducted in the area adjacent to Valve Chamber #5. Three four foot long pieces of channel iron were installed six feet off the shore line as a test anode bed. A welder was used as a D.C. power supply. The negative and positive wire from the welder was connected to the POL lines

in Valve Chamber #5 and the test anode bed respectively. The current used for this test was 62 amperes D.C.. The results of this test are shown in Table No. IV-E.

(4) Current Test No. 4 - This current test was conducted in the area adjacent to existing Rectifier #5 location. Three 3' long pieces of channel iron were installed in the stream as a test anode bed. The anode header cable fromthe test anode bed was connected to the positive terminal at Rectifier #5. The current used for this test was 6 amperes D.C.. The results of this test are shown in Table No. IV-F.

(5) Current Test No. 5 - This current test was conducted as an interference test. Pipe-to-soil potentials were obtained at various valve chambers, contact points and test stations on the Navy owned 8" JP-5 line and also obtained at representative locations on the Standard Oil Company's Rectifier was turned "off" and "on". The Standard Oil Company's rectifier, that was operating at an unknown output during this survey, is located on Waipohu Depot Street. The results of this test can be found in Table No. IV-G.

Based on the data obtained from these current tests, the following results were observed:

a. The 8" JP-5 line of Section A-4 is electrically continuous with the POL lines of Sections A-1, A-2, A-3, A-5 and C-1 and the piping system of NAS, Barbers Point Tank Farm.

b. The 8" JP-5 line is not electrically continuous with the three Standard Oil Company fuel lines and two Army owned lead cables. The Standard Oil Company owned fuel lines were also found to be electrically discontinuous with the Army owned lead cables.

c. The Standard Oil Company lines were found to be under cathodic protection.

d. No insulators were found installed on the 8" JP-5 line in VC-5 at Pearl City Tank Farm and VC-1 of Barbers Point Tank Farm.

e. Some interference was found on the Navy owned 8" JP-5 line from the Standard Oil Company rectifier.

f. The results of current tests indicated that current demand for the underground 8" JP-5 line of Section A-4 will be high.

D. Inspection of POL Lines: We were advised that damaged coating areas of the above ground 8" JP-5 lines were repaired recently by Base Fuel Department personnel.

E. Leak History: The leak history was discussed with Mr. John Kimi, Mr. Huey Manual and Mr. Albert Wong of the Base Fuel Department. No leaks on the 8" JP-5 line underground had occurred in the past. Several external leaks on the 8" JP-5 line at the bridge crossing on Waipio Point Access Road have occurred and were repaired by welding a steel patch over the leak area.

3. Conclusions.

Based on the field data obtained, the following results were observed:

A. The results of the soil resistivity measurements obtained indicate that forty-three percent of the readings are in the severe category and forty-eight percent are in the medium or moderate category. As can be seen in Table No. IV-A, most readings in the moderate category are close to the severe corrosive range. Generally, the environment of Section A-4 can be classified as an area of having severe corrosive potential.

B. The 8" JP-5 line of Section A-4 is not at a protective potential level.

C. The existing anode bed of Rectifier #5 was not installed within the easement of the 8" JP-5 line and/or on the Government property. During this survey, the anode header cable was found to be badly damaged by construction work to clear the debris out of the stream.

D. The results of the current tests conducted indicated that the current demand for Section A-4 will be high. Approximately 95,330 sq. ft. of coated steel POL lines are to be considered for cathodic protection. Approximately 80 amperes D.C. will be required to provide a protective potential for this line.

4. <u>Recommendations</u>.

A. To eliminate potential interference in the future to the Standard Oil Company fuel lines, the following recommendations are made:

(1) Install a distributive anode system by increasing the number of anode beds.

(2) Install low voltage rectifiers by increasing the number

of anodes.

(3) Install sacrificial anode beds in the area where other foreign lines are conjested.

(4) Install resistance bond stations between the 8" JP-5 lines and other metallic lines at each future anode bed location. (Impressed Current System)

B. The existing damaged anode bed of Rectifier #5 should be replaced with ten 4"x40" graphite anodes. These anodes should be installed within the easement of the JP-5 line. An anode watering system should be installed for this anode bed. The existing rectifier should be replaced with a new oil cooled rectifier. This anode bed will also provide partial protective current for the POL lines at the NAS, Barbers Point.

C. The results of current tests indicate that an additional impressed current anode bed and fourteen additional sacrificial anode beds will be required in future design.

(1) Impressed Current Anode Bed

This anode bed will consist of twelve 4½"x60" high silicon iron anodes and one oil cooled rectifier. These should be installed in the area adjacent to VC-5, in the U.S.M.C., West Loch Ammunition Depot.

(2) Sacrificial Anode Beds

A total of fourteen new anode beds should be installed at the following locations. Each anode bed will consist of one test box, five 50 lb. prepackages magnesium anodes and an anode watering system.

(a) One anode bed should be installed in the area

adjacent to VC-3.

(b) Five anode beds should be installed north of VC-3 on the west side of Waipio Point Access Road.

(c) Five anode beds should be installed between the Waiawa Stream and VC-1.

(d) Three anode beds should be installed east of the Waiawa Stream.

D. An insulating flange and a resistance bond station should be installed at each of the following locations:

(1) VC-5, Pearl City Fuel Tank Farm.

(2) VC-1, Barbers Point Fuel Tank Farm.

E. A resistance bond station should be installed between the Navy owned 8" JP-5 line and the Standard Oil Company fuel lines at each of the following locations:

(1) *West of the Waipio Stream.*

(2) Near VC-1.

F. It is recommended that the coating of the above ground JP-5 lines be inspected at least twice a year and be repaired as necessary.

G. During this survey, PCR was requested by Mr. Jim Gammon, Superintendent of the Fuel Department, NSC, to study and redesign a cathodic protection system for the proposed relocated 8" JP-5 line. The design was completed after additional field data had been obtained in October of 1981. The technical plans, specifications and calculations were submitted to Mr. Jim Gammon on October 30, 1981. It is recommended that the cathodic protection system for the proposed re-

located 8" JP-5 line be installed as designed. It is recommended that this system be isolated from the existing system by installation of test leads, insulators and resistance bond stations, as designed.

NOTE: The locations of the pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawings No. 6498 and 6499.

The recommended C.P. systems of Section A-4 are shown on PCR Drawings No. 6498-A and 6499-A.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION A-4

ESTIMATED BY: H. TSO

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ______

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
4"x40" GRAPHITE ANODES	10	ea	210.00	2100.00	150.00	1500.00	360.00	3600.00
4½"x60" HI SILICON IRON ANODES	12	ea	720.00	8640.00	150.00	1800.00	870.00	10440.00
OIL COOLED RECTIFIERS	2	ea	1950.00	3900.00	600.00	1200.00	2550.00	5100.00
50 LB. PREPACKAGED MAGNESIUM ANODES	70	ea	225.00	15750.00	150.00	10500.00	375.00	26250.00
#2 HMP STRANDED COPPER CABLE	1000	ft	1.50	1500.00	0.15	150.00	1.65	1650.00
#8 HMP STRANDED COPPER CABLE	1200	ft	0.75	900.00	0.15	180.00	0.90	1080.00
COAL COKE BREEZE	7700	ft	0.30	2310.00	0.08	616.00	0.38	2926.00
1" PVC CLASS 200, PLASTIC PIPE	1600	ft	0.75	1200.00	0.15	240.00	0.90	1440.00
CONCRETE PAD	2	ea	150.00	300.00	600.00	1200.00	750.00	1500.00
INSULATING FLANGE SET	2	ea	45.00	90.00	75.00	150.00	120.00	240.00
RESISTANCE BOND STATION	5	ea	150.00	750.00	150.00	750.00	300.00	1500.00
SPLIT BOLTS	100	ea	1.05	105.00	4.50	450.00	5.55	555.00
CONCRETE TEST BOXES/CAST IRON LIDS	19	ea	45.00	855.00	75.00	1425.00	120.00	2280.00
HOSE CONNECTION ADAPTERS	16	ea	7.50	120.00	7.50	120.00	15.00	240.00
0.01 OHM SHUNTS (1 GALLON CAN)	14	ea	7.50	105.00	7.50	105.00	15.00	210.00
COAL TAR ENAMEL	3	ea	22.50	67.50	45.00	135.00	67.50	202.50
BUTYL TAPE	3	rl	37.50	112.50	45.00	135.00	82.50	247.50

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

NAVFAC 11013/7 (1 78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 2 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION A-4

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

STATUS OF DESIGN: PED [ ] 30% [X] 100% [ ] FINAL [ ] Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
RUBBER TAPE	9	rl	4.50	40.50	7.50	67.50	12.00	108.00
PLASTIC TAPE	9	rl	4.50	40.50	7.50	67.50	12.00	108.00
TERRA TAPE	1200	ft	0.22	264.00	0.08	96.00	0.30	360.00
ALUMINO-THERMIC WELDS	45	ea	3.00	135.00	37.50	1687.50	40.50	1822.50
TRENCH	1000	ft	-	-	4.50	4500.00	4.50	4500.00
SUBTOTAL				39285.00		27074.50		66354.50
10% MISC. MATERIALS & LABOR				3928.00		2707.00		6635.00
SUBTOTAL				43213.00		29781.50		72994.50
30% CONSTRUCTION PROFIT				12963.90		8934.45		21898.35
TOTAL				56176.90		38715.95		94892.85

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

SECTION A-4

SOIL RESISTIVITIES

TABLE NO. IV-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	Near VC-5 at Pearl City Tank Farm	1200	2200	280
2.	Approximately 500' N of Rdg. 1	12000	8600	3600
3.	Approximately 200' NW of Rdg. 2	1400	680	280
4.	Approximately 300' W of Rdg. 3	310	260	400
5.	Approximately 300' W of Rdg. 4	180	240	280
6.	Approximately 400' E of VC-1	3100	2500	760
7.	Near VC-1	600	550	420
8.	Near VC-2	1000	600	560
9.	Approximately 500' W of VC-2	4600	3800	1160
10.	Approximately 500' S of Rdg. 9	170	180	200
11.	Approximately 500' S of Rdg. 10	180	200	240
12.	Approximately 500' N of VC-3	190	260	280
13.	Near VC-3	6000	1800	920
14.	Approximately 500' SW of VC-3	2000	1600	920
15.	Approximately 500' SW of Rdg. 14	2300	2100	2000
16.	Approximately 500' SW of Rdg. 15	2200	2200	2400
17.	Approximately 500' S of Rdg. 16	800	1000	960
18.	Approximately 500' S of Rdg. 17	6000	4200	4400
19.	Approximately 500' NE of VC-4	5000	4400	4800
20.	Near VC-4	1500	1600	2400
21.	NW side of VC-5	33000	30000	11200

22.	Approximately 100' SE of VC-5	28000	12000	4000
23.	Approximately 150' NW of Rdg. 21	20000	8100	2000
24.	Approximately 150' NW of Rdg. 23	7000	1400	520
25.	Near Shore Line at VC-5	150	160	200
26.	Approximately 300' S of VC-5	27000	10000	4800
27.	Approximately 300' S of Rdg. 26	28000	12000	4400
28.	Approximately 300' SW of Rdg. 27	3800	3800	3600
29.	Approximately 300' SW of Rdg. 28	4500	4400	3200
30.	Approximately 300' SW of Rdg. 29	1700	1800	3600
31.	Approximately 300' SW of Rdg. 30	2900	2200	3600
32.	Near VC-6	1000	1800	3200
33.	Approximately 400' SW of Rdg. 32	4800	3600	2400
34.	Approximately 400' SW of Rdg. 33	4500	3800	2800
35.	Approximately 400' SW of Rdg. 34	5000	3200	2800
36.	Approximately 400' SW of Rdg. 35	2700	4000	5600
37.	Near VC-7	6000	6800	8800
38.	Approximately 500' SW of VC-7	1100	1200	2400
39.	Approximately 500' SW of Rdg. 38	5000	5000	7200
40.	Near Rectifier #5	26000	36000	13200
41.	The following measurement was taken at the 20' depth near VC-5	1500		

SECTION A-4

"AS FOUND" PIPE-TO-SOIL POTENTIALS

TABLE NO. IV-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	VC-5	-650
2.	Standard Oil Station	
	White test lead	-1230
	Black test lead	-1290
	Tracer test lead	-1390
3.	Near first bridge at Waiawa Stream	
	8" JP-5	-680
	8" Standard Oil line	-1330
	6" Standard Oil line	-1390
	4" Standard Oil line	-1500
4.	Near second bridge approximately 2300' West of first bridge	
	8" JP-5	-700
	8" Standard Oil line	-620
	6" Standard Oil line	-1320
	4" Standard Oil line	-1400
	Lead cable #1	-620
	Lead cable #2	-660
5.	VC-1	-630
6.	VC-2	-620
7.	Standard Oil Co. T.B., E of Waipio Pt. access road	
	White test lead #1	-440
	Black test lead	-960
	Tracer test lead	-1390
	White test lead #2	-140
8.	Third bridge near Golf Course on Waipio Pt. access road	-680
9.	VC-3	-680
10.	VC-4	-625
11.	VC-5	-615
12.	VC-6	-600

13.	VC-7	-510
14.	Fourth bridge on Barbers Point access road near Gate #3 and Rectifier #5	-640

SECTION A-4

CURRENT TEST NO. 1

TABLE NO. IV-C

Location: Rectifier #11 at Pearl City Tank Farm.

Anodes used for current test: Existing anode bed.

Negative connection: Existing.

Rectifier D.C. Output: 7.5 volts - 27 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC-5	- 650	- 700	50
2.	Standard Oil Station			
	White test lead	-1230	-1200	-30*
	Black test lead	-1290	-1240	-50*
	Tracer test lead	-1390	-1350	-40*
3.	First Bridge			
	8" Standard Oil Line	-1330	-1320	-10*
	6" Standard Oil Line	-1395	-1390	-5*
	4" Standard Oil Line	-1500	-1495	-5*
4.	Second Bridge			
	8" Standard Oil Line	-1335	-1330	-5*
	6" Standard Oil Line	-1410	-1405	-5*
	4" Standard Oil Line	-1505	-1505	0
	8" JP-5 Line	- 690	- 720	30
	2" Lead Cable	- 640	- 635	-5*
	1" Lead Cable	- 670	- 665	-5*

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of the test current.

SECTION A-4

CURRENT TEST NO. 2

TABLE NO. IV-D

Location: VC-1.

Anodes used for current test: A junk car 6' off the shore was used as a temporary anode.

Negative connection: VC-1.

Rectifier D.C. Output: 27 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Second Bridge			
	8' Standard Oil Line	-1320	-1300	-20*
	6" Standard Oil Line	-1395	-1400	5
	4" Standard Oil Line	-1470	-1480	10
	JP-5 Line	- 700	- 940	240
	2" Lead Cable	- 630	- 590	-40*
	1" Lead Cable	- 670	- 645	-25*
2.	First Bridge			
	8" Standard Oil Line	-1360	-1330	-30*
	6" Standard Oil Line	-1410	-1390	-20*
	4" Standard Oil Line	-1510	-1495	-15*
	8" JP-5	- 715	- 805	90
3.	VC-2	- 635	- 900	265
4.	Standard Oil Co. T.S.			
	White test lead	-1235	-1255	20
	Black test lead	- 980	-1030	50
	Tracer test lead	-1375	-1400	25

5.	JP-5 at Bridge near Golf Course	- 720	- 815	95
6.	VC-3	- 710	- 750	40
7.	VC-4	- 625	- 635	10
8.	VC-5 at Pearl City Tank Farm	- 710	- 720	10

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION A-4

CURRENT TEST NO. 3

TABLE NO. IV-E

Location: VC-5.

Anodes used for current test: Three, four foot long pieces of channel iron were used as temporary anodes installed approximately 6' off the shore line near VC-5.

Negative connection: VC-5.

Rectifier D.C. Output: 62 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC-4	- 640	-1730	1090
2.	VC-3	- 720	- 980	260
3.	By Bridge near Golf Course	- 740	- 810	70
4.	Standard Oil Co. test station N of Waipio Point Access Road			
	White test lead	-1280	-1260	-20*
	Black test ead	-1260	-1250	-10*
	Tracer test lead	-1400	-1395	-5*
5.	VC-2	- 635	- 670	35
6.	VC-6	- 700	-1900	1200
7.	VC-7	- 385	-1500	1115
8.	By Existing Rectifier #5	- 620	-1360	740
9.	VC-1 at Barbers Point	- 660	-1300	640
10.	Test station near Bldg. 92 at Barbers Point			
	Test leads connected	- 520	- 600	80

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of the test current.

SECTION A-4

CURRENT TEST NO. 4

TABLE NO. IV-F

Location:	Near existing Rectifier #5.
Anodes uded for current test:	Three, 3' long pieces of channel iron were installed in the stream as temporary anodes.
Negative connection:	Existing.
Rectifier D.C. Output:	6 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC-6	-760	-1040	280
2.	VC-7	-730	-1140	410
3.	Test station near Bldg. 92			
	Test leads connected	-480	- 540	60

SECTION A-4

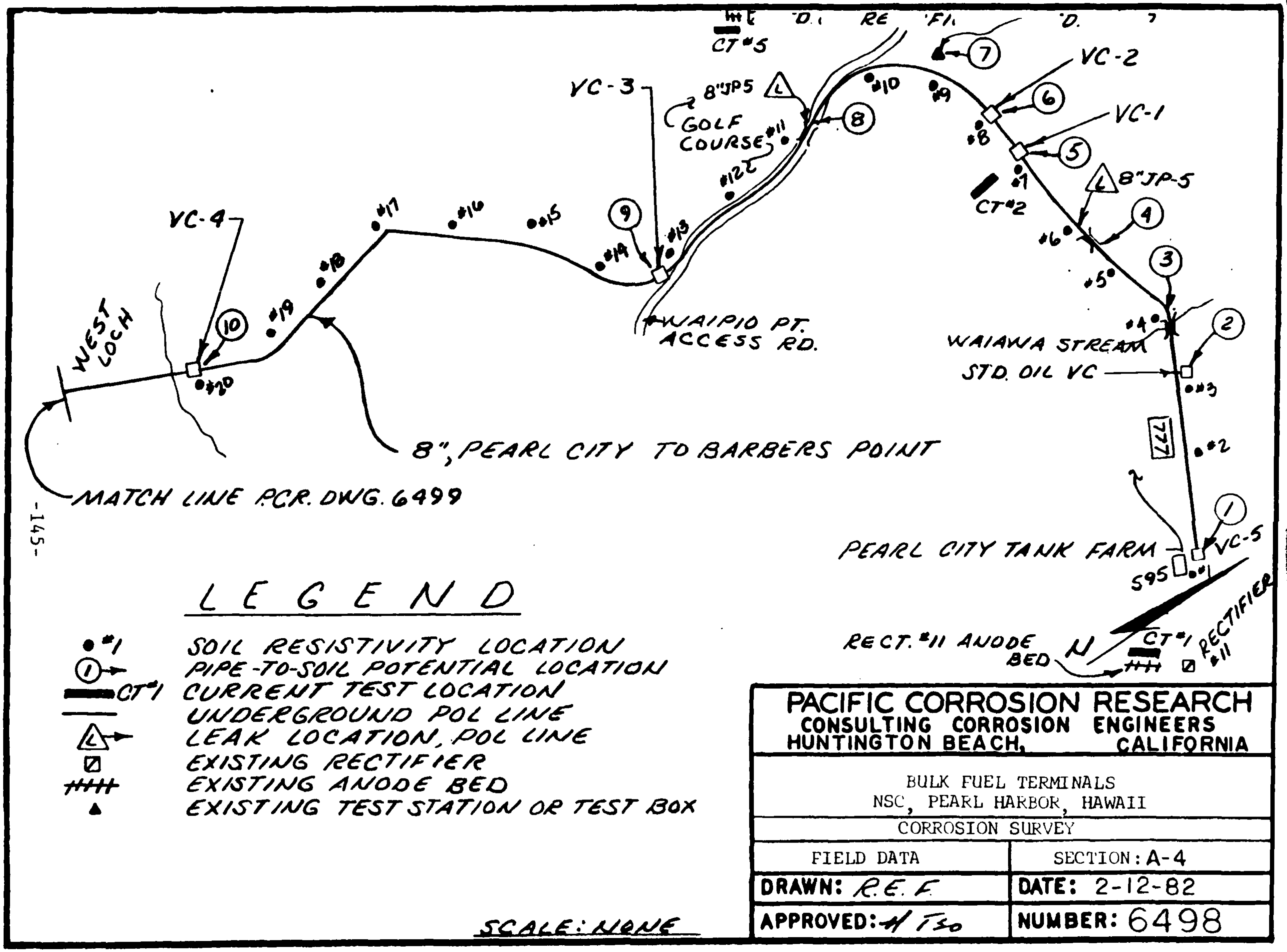
CURRENT TEST NO. 5

TABLE NO. IV-G

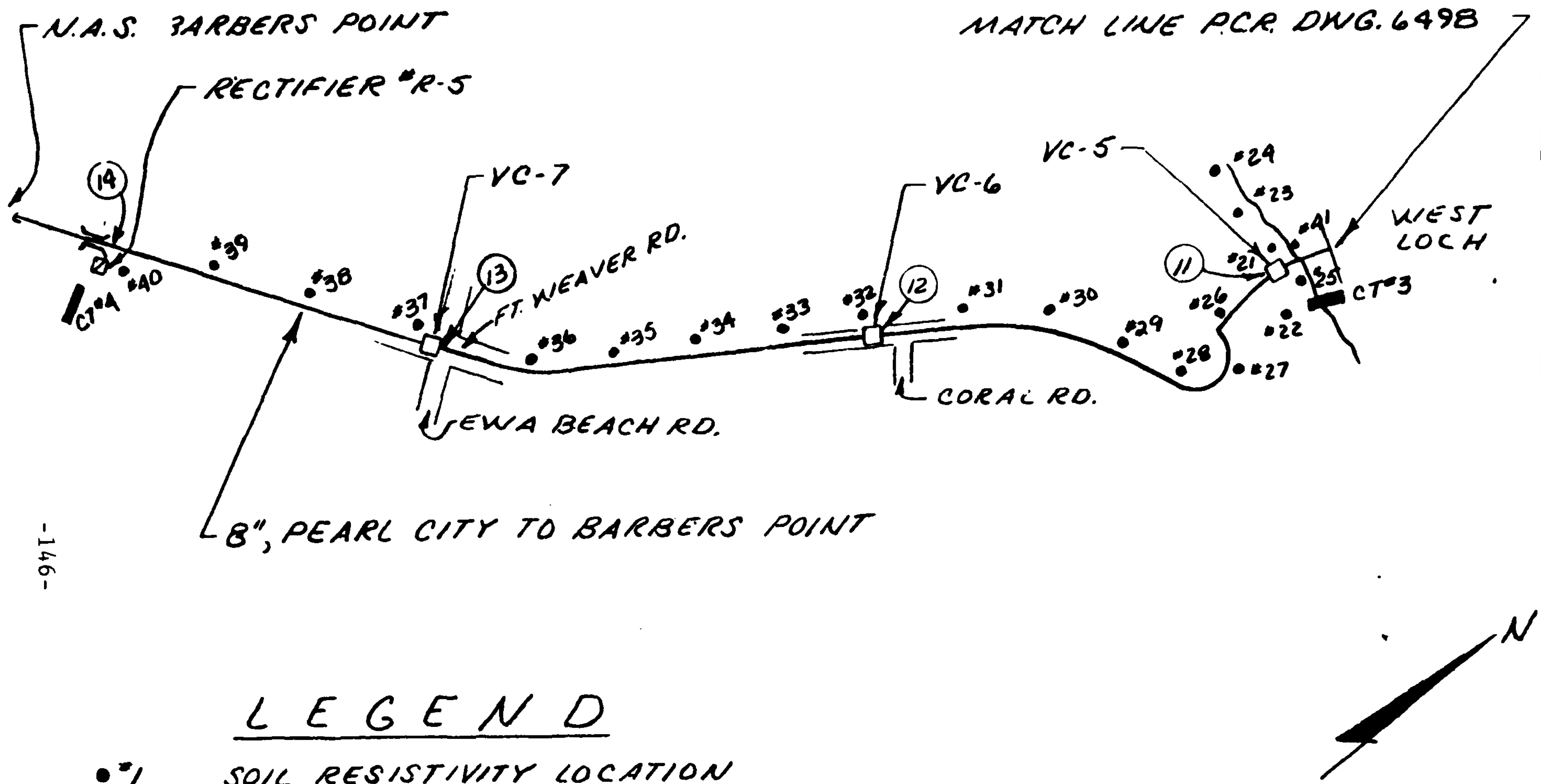
Location:	Standard Oil Rectifier at Waipalm Depot Road
Anodes used for current test:	Existing.
Negative connection:	Existing.
Rectifier D.C. Output:	Unknown.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	By Bridge at Golf Course on Waipio Point Access Road			
	JP-5 Line	- 740	- 730	-10*
2.	VC-3			
	8" JP-5 Line	- 700	- 700	0
3.	Standard Oil Co. Test Station N of Waipio Point Access Road			
	White test lead	-1180	-1240	60
	Black test lead	- 990	-1110	120
	Tracer test lead	-1200	-1370	170
4.	VC-2			
	8" JP-5 Line	- 630	- 625	- 5*

*A minus change indicates that the pipe-to-soil potential became less negative as a result of the application of test current.



VC-4
VC-3
VC-2
VC-1
VC-5
WEST LOCH
MATCH LINE P.C.R. DWG. 6499
8", PEARL CITY TO BARBERS POINT
WAIPIO PT. ACCESS RD.
GOLF COURSE
8"JP5
8"JP-5
CT#5
CT#2
CT#1
WAIAWA STREAM
STD. OIL VC
777
PEARL CITY TANK FARM
595
RECT. #11 ANODE BED
RECTIFIER #11
LEGEND
SOIL RESISTIVITY LOCATION
PIPE-TO-SOIL POTENTIAL LOCATION
CURRENT TEST LOCATION
UNDERGROUND POL LINE
LEAK LOCATION, POL LINE
EXISTING RECTIFIER
EXISTING ANODE BED
EXISTING TEST STATION OR TEST BOX
SCALE: NONE
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA
BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII
CORROSION SURVEY
FIELD DATA
SECTION: A-4
DRAWN: R.E.F.
DATE: 2-12-82
APPROVED: H Tso
NUMBER: 6498



LEGEND

- #1 SOIL RESISTIVITY LOCATION
- 1 PIPE-TO-SOIL POTENTIAL LOCATION
- CT#1 CURRENT TEST LOCATION
- UNDERGROUND POL LINE
- EXISTING RECTIFIER

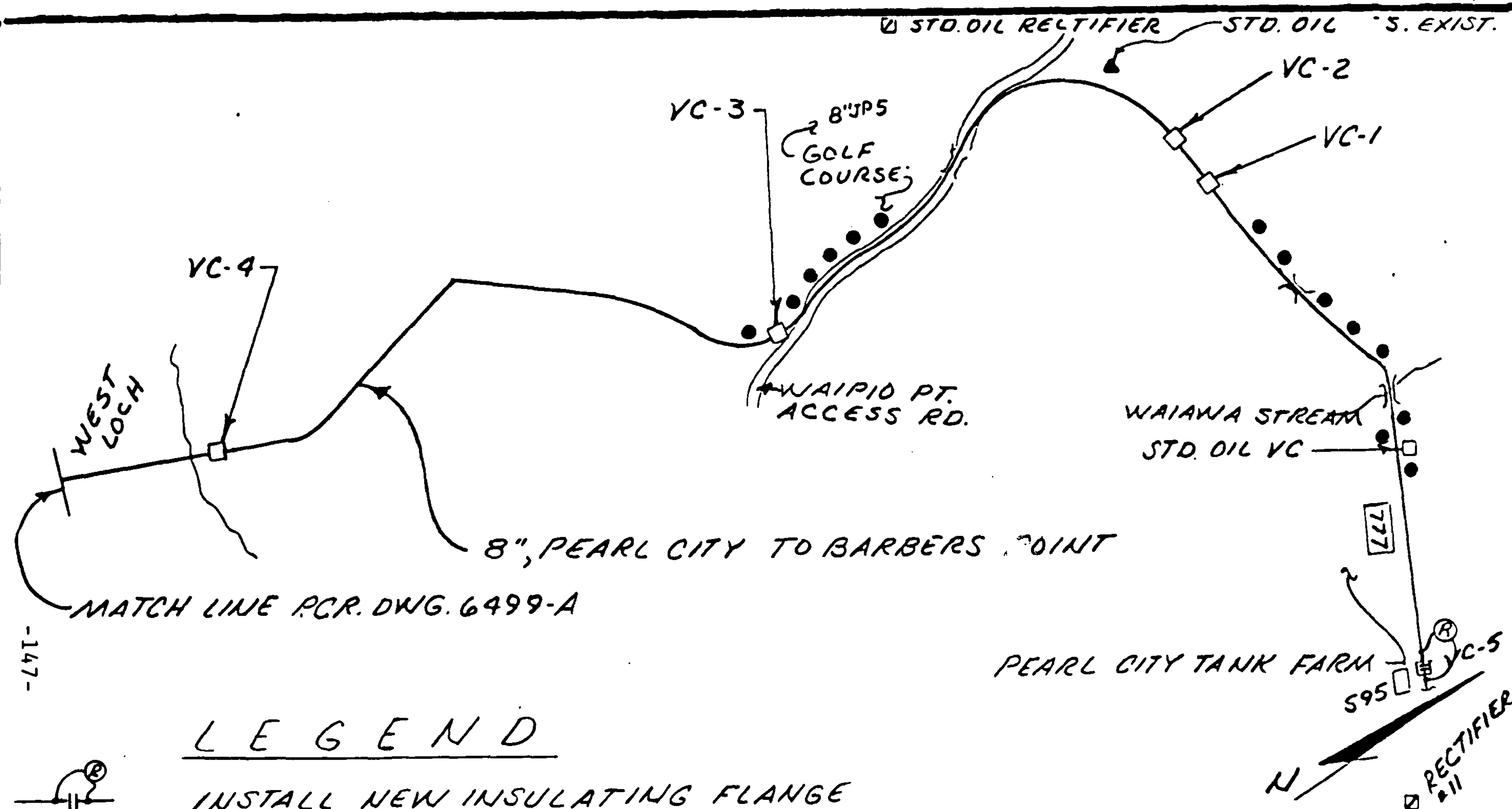
SCALE: NONE

PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA

BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII

CORROSION SURVEY

FIELD DATA	SECTION: A-4
DRAWN: R.E.F.	DATE: 2-12-82
APPROVED: N. Tso	NUMBER: 6499



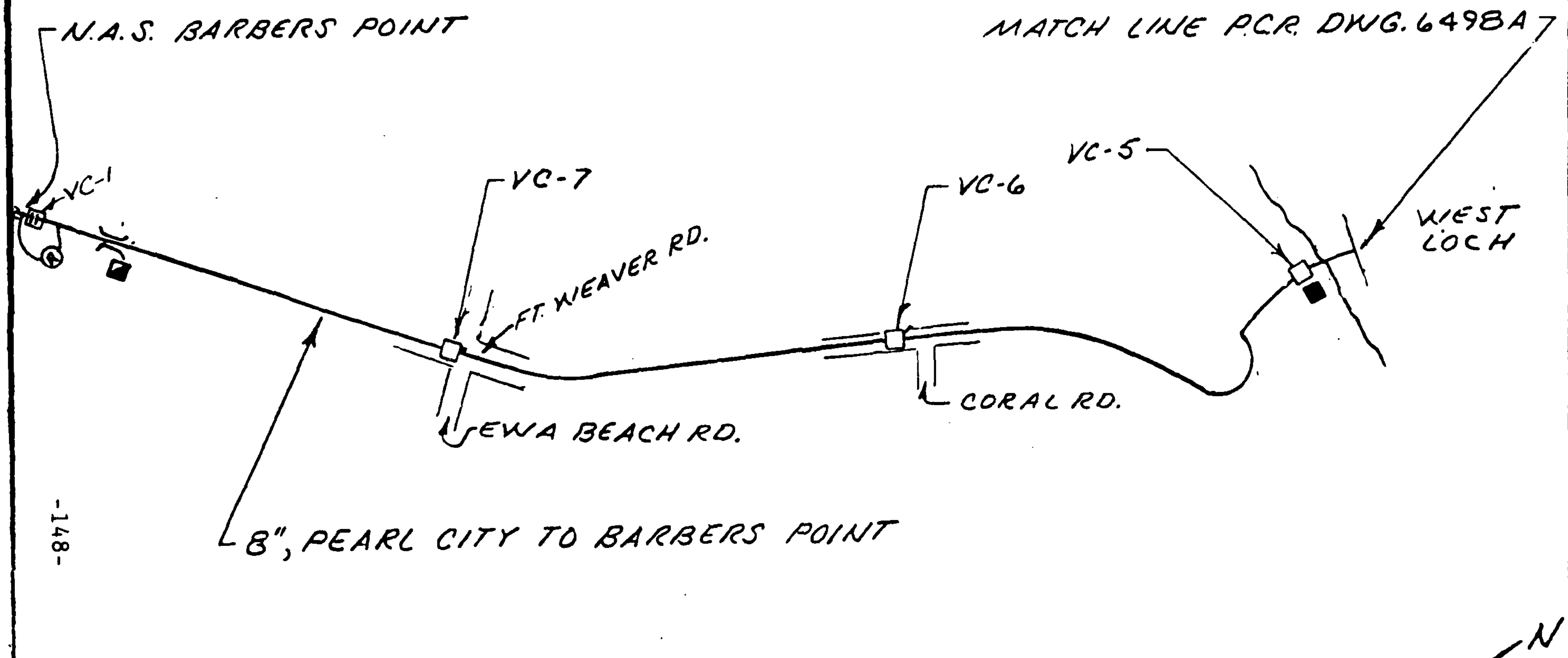
LEGEND

INSTALL NEW INSULATING FLANGE SET AND RESISTANCE BOND STATION.

● INSTALL NEW TEST BOX AND INSTALL PREPACKAGED MAGNESIUM ANODES.

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED C.P. SYS.	SECTION: A-4
DRAWN: R.E.F.	DATE: 2-12-82
APPROVED: H T30	NUMBER: 6498-A



LEGEND

INSTALL INSULATING FLANGE SET AND RESISTANCE BOND STATION.

■ INSTALL NEW OIL COOLED RECTIFIER AND INSTALL HIGH SILICON IRON TUBULAR ANODES

◪ REPLACE EXIST. RECTIFIER #5 WITH A NEW OIL COOLED RECTIFIER AND INSTALL HIGH SILICON IRON TUBULAR ANODES

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED C.P. SYS.	SECTION: A-4
DRAWN: R.E.F.	DATE: 2-12-82
APPROVED: H. T.Sr	NUMBER: 6499 A

SECTION A-5

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE INTERCONNECTING LINES FROM THE PUMPHOUSE AT THE

PEARL CITY PENINSULA

SECTION A-5

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX INCLUDING THE INTERCONNECTING LINES FROM THE PUMPHOUSE AT THE PEARL CITY PENINSULA

SECTION A-5

SUMMARY

1. Conclusions:

Based on the field data obtained the following results were observed:

A. The soil environment in Section A-5 can be classified as an area of severe corrosion potential.

B. The POL lines of Section A-5 are not at a protective potential level with all potentials below -850 mv.

C. The POL lines of this section are electrically continuous with the POL lines of Sections A-1, A-2, A-3, A-4 and C-1 but are electrically discontinuous with the water and foam lines.

D. The HIRI owned fuel storage tank and the 10" HIRI line to Fuel Station S-777 are to be protected by HIRI and were found to be electrically isolated from the Navy owned piping system.

E. The 10" Mogas and 10" Avgas lines to Ewa Junction are isolated from the Navy owned fueling system with insulating flanges in VC-1 and VC-1A.

F. Approximately 20,215 sq. ft. of coated steel POL lines are to be considered for cathodic protection in Section A-5. Approximately 35 amperes D.C. will be required to accomplish this achievement.

2. Recommendations:

A. The current tests conducted indicated that one additional anode bed will be required to provide protection for the underground POL lines and the exterior bottom areas of the fuel storage tanks (Section C-1).

It is recommended that this anode bed consist of fourteen (14) 4½" x60" high silicon iron anodes and a new oil cooled rectifier installed in the area north of Tank #3.

B. The existing anode bed of Rectifier #11 should be replaced with fourteen (14) 4½"x60" high silicon iron anodes. These anodes should be installed near the existing anode bed location. The existing rectifier should be replaced with a new oil cooled rectifier.

C. To eliminate interference to the 10" HIRI line, water main and foam line, it is recommended a resistance bond station be installed at each of the following locations:

(1) Between the HIRI line and the POL line south of Tank #4.

(2) Between the foam line and the POL line west of Pumphouse S86.

(3) Between the water line and the POL line east of VC-1 and VC-1A.

SECTION A-5

POL LINES OUTSIDE THE PEARL HARBOR COMPLEX, INCLUDING THE INTERCONNECTING LINES FROM PUMPHOUSE AT PEARL CITY PENINSULA

1. Description.

A. Lines to be Protected:

(1) From Tank #4 (S87) to Fuel Station S-777

a.	12" JP-4 Line	-	Coated Steel
b.	20" Suction and Fill Line	-	Coated Steel

(2) From Tank #4 (S87) to VC-3

a.	12" JP-4 Line	-	Coated Steel

(3) From Tank #3 (S88) to VC-1 and VC-1A

a.	12" Suction Line	-	Coated Steel

(4) From Tank #3 (S88) to VC-1 and VC-1A

a.	12" Fill Line	-	Coated Steel

(5) From Fuel Station S-777 to VC-10

a.	10" Mogas Line	-	Coated Steel
b.	10" Avgas Line	-	Coated Steel

(6) From VC-1 and VC-A to VC-3

a.	12" Mogas Line	-	Coated Steel
b.	12" Avgas Line	-	Coated Steel

(7) From Fuel Station S-777 to North S-776

a.	8" Multi Line	-	Coated Steel

(8) From VC-3 to VC-4

a.	12" Suction Line (Tank #1)	-	Coated Steel
b.	12" Suction Line (Tank #2)	-	Coated Steel

c. 12" Suction Line

(Tank #3) - Coated Steel

(9) <u>From VC-1 and VC-1A to Pump Station S85</u>

a. 10" Avgas Line - Coated Steel

(10) <u>From VC-1 and VC-1A to VC-9</u>

a. 12" JP-4 Line - Coated Steel

(11) <u>From VC-5 to Jet Fuel Loading Rack</u>

a. 6" JP-4 Line - Coated Steel

(12) <u>From Valve Chamber, east of S-777 to VC-5</u>

a. 8" JP-5 Line - Coated Steel

(13) <u>From S85 to Mogas Loading Rack</u>

a. 6" Mogas Line - Coated Steel

(14) <u>From S85 to Avgas Loading Rack</u>

a. 6" Avgas Line - Coated Steel

(15) <u>From Tank B-1 (S-775) to VC-12</u>

a. 12" Fill Line - Coated Steel

(16) <u>From Tank B01 (S-775) to S-776</u>

a. 3" Suction Line - Coated Steel

(17) <u>From Tank #2 (S94) to VC-4</u>

a. 12" Suction Line - Coated Steel

(18) <u>From Tank #2 (S94) to S98</u>

a. 12" Fill Line - Coated Steel

(19) <u>From Tank #1 (S93) to S-776</u>

a. 3" Ballast Line - Coated Steel

(20) <u>From Tank #1 (S93) to S98</u>

a. 12" Fill Line - Coated Steel

(21) <u>From Mogas Loading Rack to S-776</u>

a. 3" Ballast Line - Coated Steel

B. Existing Cathodic Protection System:

The POL lines of Section A-5, a portion of POL lines of Section A-2 and external bottom surface areas of fuel tanks (Section C-5) was to be protected by existing Rectifier #11.

a. Rectifier Location:	Rectifier #11 is located southwest of the Pearl City Tank Farm.
b. Rectifier Unit:	Mfg. - Electrical Facilities, Inc. Oakland, CA. Serial No. - Unknown (no name plate) D.C. Capacity - 20 V, 50 A Operating at - Tap setting 5-4 D.C. Output - 3.5 V, 13 A Date Recorded - October 10, 1981
c. Anode Bed Location:	Three sections of railroad tracks were installed 5' east of Kalapo canal and approximately 350' north of Waipuna Ave.

2. Field Work and Evaluation of Data.

A. Soil Resistivity Measurements: A total of nine sets of measurements were obtained at representative locations as shown in Table No. V-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	78	Severe
Medium	2,000 - 10,000	22	Moderate
High	10,000 - 30,000	0	Slight, unless other factors are pronounced
Very High	Above - 30,000	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on under ground metallic structures. Seventy-eight percent of the measurements obtained were in the severe category and twenty-two percent were in the medium or moderate category.

B. "As Found" Pipe-to-Soil Potentials: "As Found" pipe-to-soil potentials were obtained at each valve chamber and at each test station. The measurements obtained indicated that the POL lines of Section A-5 are not receiving full protection with all readings below -850 mv. Lower potentials were found in the northern portion of the Pearl City Tank Farm. The results of these measurements are shown in Table No. V-B.

C. Current Tests: Three current tests were conducted on this section of POL lines. Pipe-to-soil potential were obtained at the same locations as "As Found" potentials with the test rectifier "off" and "on".

(1) Current Test No. 1 - Current Test No. 1 was conducted with existing Rectifier #11 turned "off" and "on". During this test, Rectifier #11 was operating at a tap setting of 5 (coarse) - 4 (fine), providing 3.5 volts and 13 amperes D.C.. The results of this test are shown in Table No. V-C.

(2) Current Test No. 2 - Current Test No. 2 was conducted with the same rectifier as Current Test No. 1. During this test, the tap setting of Rectifier #11 was adjusted to a new tap setting of 10 (coarse) - 4 (fine), providing 7.5 volts and 27.5 amperes D.C.. The results of this test are shown in Table No. V-D.

(3) Current Test No. 3 - This test was conducted in the area north of Tank #3. Fifteen steel rods were installed north of Tank #3 as a temporary anode bed. The negative from a test rectifier was connected to the 12" JP-4 line in VC-3. The current used for this test was 24 amperes D.C.. During this test, Rectifier #11 was turned "on" at all times and was operating at a tap setting of 10 (coarse) - 4 (fine), providing 7.5 volts and 27.5 amperes. The results of this test are shown in Table No. V-E.

Based on the data obtained from these tests, the following results were observed:

a. The POL lines of Section A-5 are electrically continuous with the POL lines of Sections A-2, A-3 and C05.

b. Existing Rectifier #11 does not provide adequate protection

for the POL lines of Section A-5.

c. The underground HIRI line is isolated from the above ground line at the Fuel Station S-777. The under ground HIRI line and the HIRI owned fuel storage tank are cathodically protected by HIRI.

d. An insulator was found installed at each of the following POL lines:

(i) 10" Avgas line ("A") at S-777.

(ii) 10" Avgas line ("B") at S-777.

(iii) 18" JP-4 line to Victor Docks, at S-777.

(iv) 16" JP-5 line to Red Hill at S-777.

(v) 10" Mogas line to Ewa Junction in VC-1 and VC-1A.

(vi) 10" Mogas line to Ewa Junction in VC-1 and VC-1A.

D. Inspection of Pipelines: All POL lines of Section A-5 are underground. No excavations were made during this survey.

E. Leak History: The leak history was discussed with Mr. Huey Manual, Fuel Farm Foreman, Pearl City Tank Farm, that several leaks have occurred on the "B" line between VC-1 and VC-1A since 1969. Only one leak on the 12" fill line to Tank #3 was found in 1958. The leak locations are shown on PCR Drawing No. 6500.

3. Conclusions.

Based on the field data obtained, the following results were observed:

A. Soil resistivity measurements indicate that 78% of the readings are in the severe category and 22% are in the moderate category. The environment in Section A-5 can be classified as an area of severe corrosion potential.

B. The POL lines of Section A-5 are not at a protective potential level with all potentials below -850 mv.

C. The POL lines of this section are electrically continuous with the POL lines of Sections A-1, A-2, A-3, A-4 and C-1 but electrically discontinuous with the water and foam lines.

D. The HIRI owned fuel storage tank and the 10" HIRI line to the Fuel Station S-777 are to be protected by HIRI and were found to be electrically isolated from the Navy owned piping system.

E. The 10" Mogas and 10" Avgas line to Ewa Junction are isolated from the Navy owned fueling system with insulating flanges in VC-1 and VC-1A.

F. The results of current tests conducted indicated the current demand will be moderate. Approximately 20,215 sq. ft. of coated steel POL lines to be considered for cathodic protection in Section A-5. Approximately 35 amperes D.C. will be required to accomplish this achievement.

4. Recommendations.

A. The current tests conducted indicated that one additional anode bed will be required to provide protection for the underground POL lines and the exterior bottom areas of the fuel storage tanks (Section C-1).

It is recommended that this anode bed consist of fourteen 4½"x60" high silicon iron anodes and a new oil cooled rectifier installed in the area north of Tank #3. An anode watering system should be installed for this anode bed.

B. The existing anode bed of Rectifier #11 should be replaced with fourteen 4½"x60" high silicon iron anodes. These anodes should be installed near the existing bed location. The existing rectifier should be replaced with a new oil cooled rectifier.

C. To eliminate interference to the 10" HIRI line, water main and the foam line, it is recommended a resistance bond station be installed at each of the following locations:

   (1) Between the HIRI line and the POL line south of Tank #4.

   (2) Between the foam line and the POL line west of Pump-house S86.

   (3) Between the water line and the POL line east of VC-1 and VC-1A.

NOTE: The locations of the pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No. 6500.

The recommended C.P. systems for Section A-5 is shown on PCR Drawing No. 6500-A.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982 | SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM CORROSION SURVEY, SECTION A-5

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ______

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
4½"x60" HI SILICON IRON ANODES	28	ea	720.00	20160.00	150.00	4200.00	870.00	24360.00
OIL COOLED RECTIFIERS	2	ea	1950.00	3900.00	600.00	1200.00	2550.00	5100.00
COAL COKE BREEZE	9800	lb	0.30	2940.00	0.08	784.00	0.38	3724.00
CONCRETE PAD	2	ea	150.00	300.00	600.00	1200.00	750.00	1500.00
#2 HMP STRANDED COPPER CABLE	900	ft	1.50	1350.00	0.15	135.00	1.65	1485.00
RESISTANCE BOND STATION	3	ea	150.00	450.00	150.00	450.00	300.00	900.00
1" PVC CLASS 200, PLASTIC PIPE	1600	ft	0.75	1200.00	0.15	240.00	0.90	1440.00
SPLIT BOLTS	40	ea	1.05	42.00	4.50	180.00	5.55	222.00
COAL TAR ENAMEL (1 GALLON CAN)	1	ea	22.50	22.50	45.00	45.00	67.50	67.50
BUTYL TAPE	3	rl	37.50	112.50	45.00	135.00	82.50	247.50
RUBBER TAPE	9	rl	4.50	40.50	7.50	67.50	12.00	108.00
PLASTIC TAPE	9	rl	4.50	40.50	7.50	67.50	12.00	108.00
TERRA TAPE	1200	ft	0.22	264.00	0.08	96.00	0.30	360.00
ALUMINO-THERMIC WELDS	10	ea	3.00	30.00	27.50	375.00	40.50	405.00
TRENCH	1000	ft	-	-	4.50	4500.00	4.50	4500.00
SUBTOTAL				30852.00		13675.00		44527.00
10% MISC. MATERIALS & LABOR				3085.00		1367.00		4452.00

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM CORROSION SURVEY, SECTION A-5

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
SUBTOTAL				33937.00		15042.00		48979.00
30% CONSTRUCTION PROFIT				10181.10		4512.60		14693.70
TOTAL				44118.10		19554.60		63672.70

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

SECTION A-5

SOIL RESISTIVITIES

TABLE NO. V-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	NE of Tank S93	3700	2600	760
2.	Near VC-2	3800	2800	720
3.	NE of Tank S94	3800	2600	760
4.	E of Tank S775	1600	1000	660
5.	N of Jet Fuel Loading Rack	800	560	360
6.	NE of Tank S88	900	310	280
7.	Near VC-11	1200	340	320
8.	100' W of Bldg. S86	1100	420	360
9.	SE of Tank S87	1200	440	480

SECTION A-5

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. V-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	VC, E of Bldg. S777	
	8" JP-5 Line to Bldg. S777	- 745
2.	Bldg. S777	
	10" HIRI Line	
	HIRI side of Ins.	- 930
	10" HIRI Line	
	Navy side of Ins.	- 625
	12" JP-4 Line	- 625
	10" JP-5 Line	- 625
	16" JP-5 Line	
	Above ground side of Ins.	- 665
	Underground side of Ins.	- 705
	18" JP-4 Line	
	Above ground side of Ins.	- 665
	Underground side of Ins.	- 755
	12" Line B	- 630
	12" Line A	- 640
3.	VC-1 and VC-1A	
	10" Mogas Line	
	EWA side of Ins.	- 710
	Navy side of Ins.	- 760
	10" Avgas Line	
	EWA side of Ins.	- 710
	Navy side of Ins.	- 760
	12" Mogas Line to VC-3	- 760
	12" Avgas Line to VC-3	- 760
	16" JP-4 to Victor Docks	- 760
	10" Mogas Line to VC-9 & VC-10	- 760
	10" Avgas Line to VC-9 & VC-10	- 760
	12" JP-4 Line to VC-11	- 760
	10" Avgas Line to S85	- 760
	12" Fill Line to Tank S88	- 760
4.	F.H. #45, E of VC-1 & VC-1A	- 560
5.	Bldg. S95	
	All Lines	- 740
6.	VC-4	
	All Lines	- 690

7.	VC-3	
	All Lines	- 670
8.	Tank #4 (S87)	
	At Tank	- 670
	12" JP-4 Line (valve dropped at Tank)	- 670
	20" Suction & Fill Line (valve dropped at tank)	- 650
	12" JP-4 Line from VC-3 (valve dropped at tank)	- 655
9.	Tank #3 (S88)	
	At Tank	- 760
	12" Suction Line	- 760
	12" Fill Line	- 775
10.	F.H. (foam line) between Tanks #3 & #4	- 515
11.	Separator, 2" Line	- 715
12.	HIRI Tank, SW of Tank #4	1060
13.	Fuel Loading Rack	
	Avgas Line	- 780
	Mogas Line	- 780
14.	Bldg. S776	
	3" Ballast Line to VC-2	- 775
	3" Ballast Line to Loading Rack	- 775
15.	6" Water Line, 10' N of Bldg. S776	- 745
	6" AFFF Line, N of Bldg. S776	- 620
	8" MP. Line, N of Bldg. S776	- 775
16.	VC-12	
	All Lines	- 780
17.	Tank #2 (S94)	
	At Tank	- 790
	12" Suction Line	- 790
	12" Fill Line	- 795
18.	Bldg. S98, VC-2	
	All Lines	- 760
19.	Tank #1 (S93)	
	At Tank	- 830
	12" Suction Line	- 830
	12" Fill Line	- 840
20.	VC-9 & VC-10	- 850

21.	Existing test station E side of Lehua Ave. & SE of VC-12	
	Navy side	- 890
	Foreign side	- 850
22.	At Tank B-1 (S775)	- 750
	12" Fill Line	- 850
	3" Suction Line	- 870

SECTION A-5

CURRENT TEST NO. 1

TABLE NO. V-C

Location:	Existing Rectifier #11 Southwest corner of the Pearl City Tank Farm
Anodes used for current test:	Existing anode bed.
Negative Connection:	Existing.
Rectifier D.C. Output:	3.5 volts - 13 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC E of S777			
	8" JP-5 Line to S777	- 740	- 745	5
2.	Bldg. S777			
	10" HIRI Line			
	HIRI side of Ins.	- 960	- 930	-30*
	Navy side of Ins.	- 620	- 625	5
	12" JP-4 Line	- 620	- 625	5
	10" JP-5 Line	- 620	- 625	5
	16" JP-5 Line			
	Above ground side of Ins.	- 660	- 665	5
	Below ground side of Ins.	- 700	- 705	5
	18" JP-4 Line			
	Above ground side of Ins.	- 660	- 665	5
	Below ground side of Ins.	- 750	- 755	5
	12" Line B	- 630	- 630	0
	12" Line A	- 640	- 640	0
3.	VC-1 & VC-1A			
	10" Mogas Line			
	Ewa side of Ins.	- 700	- 710	10
	Navy side of Ins.	- 750	- 760	10
	10" Avgas Line			
	Ewa side of Ins.	- 700	- 710	10
	Navy side of Ins.	- 750	- 760	10
	12" Mogas Line to VC-3	- 750	- 760	10
	12" Avgas Line to VC-3	- 750	- 760	10
	16" JP-4 to Victor Docks	- 750	- 760	10
	10" Mogas to VC-9 & VC-10	- 750	- 760	10
	10" Avgas to VC-9 & VC-10	- 750	- 760	10

	12" JP-4 to VC-11	- 750	- 760	10
	10" Avgas to S85	- 750	- 760	10
	12" Fill Line to Tank S88	- 750	- 760	10
4.	FH. #45 E, VC-1 & VC-1A	- 560	- 560	0
5.	Bldg. S95			
	All Lines	- 710	- 740	30
6.	VC-4			
	All Lines	- 675	- 690	15
7.	VC-3			
	All Lines	- 660	- 670	10
8.	Tank #4 (S87)			
	At Tank	- 650	- 670	20
	12" JP-4 Line (valve dropped at tank)	- 650	- 670	20
	20" Suction & Fill Line (valve dropped at tank)	- 640	- 650	10
	12" JP-4 Line from VC-3 (valve dropped at tank)	- 635	- 655	20
9.	Tank #3 (S88)			
	At Tank	- 710	- 760	50
	12" Suction Line	- 710	- 760	50
	12" Fill Line	- 710	- 760	50
10.	FH. (Foam Line) between Tanks #3 & #4	- 490	- 515	25
11.	Separator, 2" Line	- 700	- 715	15
12.	HIRI Tank, SW of Tank #4	-1040	-1060	20
13.	Fuel Loading Rack			
	Avgas Line	- 740	- 780	40
	Mogas Line	- 740	- 780	40
14.	Bldg. S776			
	3" Ballast line to VC-2	- 740	- 775	35
	3" Ballast line to Loading Rack	- 740	- 775	35
15.	6" Water line 10' N of Bldg. S776	- 710	- 745	35
	6" AFFF Line N of Bldg. S776	- 580	- 620	40
	8" M.P. Line N of Bldg. S776	- 740	- 775	35
16.	VC-12			
	All Lines	- 720	- 780	60

17.	Tank #2			
	At Tank	- 720	- 790	70
	12" Suction Line	- 720	- 790	70
	12" Fill Line	- 720	- 795	75
18.	Bldg. S98			
	All Lines	- 690	- 790	70
19.	Tank #1 (S93)			
	At Tank	- 740	- 830	90
	12" Suction Line	- 740	- 830	90
	12" Fill Line	- 740	- 830	90
20.	VC-9 & VC-10	- 740	- 850	90
21.	Existing test station E side of Lehua Ave. & SE of VC-12			
	Navy side	- 820	- 890	80
	Foreign Line side	- 810	- 850	40
22.	Tank B01 (S775)			
	At Tank	- 760	- 850	90
	12" Fill Line	- 760	- 850	90
	3" Suction Line	- 770	- 870	100

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION A-5

CURRENT TEST NO. 2

TABLE NO. V-D

Location:	Existing Rectifier #11, Southwest corner of the Pearl City Tank Farm.
Anodes used for current test:	Existing Anode bed.
Negative Connection:	Existing.
Rectifier D.C. Output:	For this current test, Rectifier #11 was adjusted to a settin of 7.5 volts - 27.5 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC, E of S777			
	8" JP-5 Line S777	- 740	- 765	25
2.	Bldg. S777			
	10" HIRI LIne			
	HIRI side of Ins.	- 960	- 940	-20*
	Navy side of Ins.	- 620	- 715	95
	12" JP-4 Line	- 620	- 715	95
	10" JP-5 Line	- 620	- 715	95
	16" JP-5 Line			
	Above ground side of Ins.	- 660	- 720	60
	Below ground side of Ins.	- 700	- 715	15
	18" JP-4 Line			
	Above ground side of Ins.	- 660	- 720	60
	Below ground side of Ins.	- 750	- 775	25
	12" Line B	- 620	- 690	70
	12" Line A	- 640	- 720	80
3.	VC-1 & VC-1A			
	10" Mogas Line			
	Ewa side of Ins.	- 700	- 770	70
	Navy side of Ins.	- 750	- 800	50
	10" Avgas Line			
	Ewa side of Ins.	- 700	- 770	70
	Navy side of Ins.	- 750	- 800	50
	12" Mogas Line to VC-3	- 750	- 800	50
	12" Avgas Line to VC-3	- 750	- 800	50

	16" JP-4 to Victor Docks	- 750	- 800	50
	10" Mogas to VC-9 & VC-10	- 750	- 800	50
	10" Avgas to VC-9 & VC-10	- 750	- 800	50
	12" JP-4 to VC-11	- 750	- 800	50
	10" Avgas to S85	- 750	- 800	50
	12" Fill Line to Tank S88	- 750	- 800	50
4.	FH. #45, E of VC-1 & VC-1A	- 560	- 555	- 5*
5.	Bldg. S95			
	All Lines	- 710	- 800	90
6.	VC-4			
	All Lines	- 675	- 850	175
7.	VC-3			
	All Lines	- 660	- 900	240
8.	Tank #4 (S87)			
	At Tank	- 650	- 760	110
	12" JP-4 Line (valve dropped at tank)	- 650	- 775	125
	20" Suction & Fill Line (valve dropped at tank)	- 640	- 785	150
	12" JP-4 Line from VC-3 (valve dropped at tank)	- 635	- 785	150
9.	Tank #3 (S88)			
	At Tank	- 710	- 880	170
	12" Suction Line	- 710	- 880	170
	12" Fill Line	- 710	- 940	230
10.	FH. (Foam Line) between Tanks #3 & #4	- 490	- 510	20
11.	Separator, 2" Line	- 700	- 980	280
12.	HIRI Tank, SW of Tank #4	-1040	-1175	135
13.	Fuel Loading Rack			
	Avgas Line	- 740	- 780	40
	Mogas Line	- 740	- 780	40
14.	Bldg. S776			
	3" Ballast Line to VC-2	- 740	-1120	380
	3" Ballast Line to Loading Rack	- 740	-1120	380
15.	6" Water Line, 10' N of Bldg. S776	- 710	- 920	210
	6" AFFF Line, N of Bldg. S776	- 580	- 780	200
	8" M.P. Line N of Bldg. S776	- 740	- 780	40

16.	VC-12			
	All Lines	- 720	- 950	230
17.	Tank #2			
	At Tank	- 720	- 990	270
	12" Suction Line	- 720	- 990	270
	12" Fill Line	- 730	- 935	205
18.	Bldg. S98			
	All Lines	- 690	- 950	260
19.	Tank #1			
	At Tank	- 740	-1040	300
	12" Section Line	- 740	-1040	300
	12" Fill Line	- 750	- 940	190
20.	VC-9 & VC-10	- 750	- 950	200
21.	Existing test station E side of Lehua Ave. & SE of VC-12			
	Navy side	- 820	- 940	120
	Foreign Line side	- 810	- 920	110
22.	Tank B-1 (S775)			
	At tank	- 760	-1070	310
	12" Fill Line	- 760	-1070	310
	3" Suction Line	- 770	-1080	310

*A minus change indicates that the pipe-to-soil potential became less negative as a result of applicaiton of test current.

SECTION A-5

CURRENT TEST NO. 3

TABLE NO. V-E

Location: Between tanks 3 & 4.

Anodes used for current test: Fifteen steel rods were installed as temporary anodes.

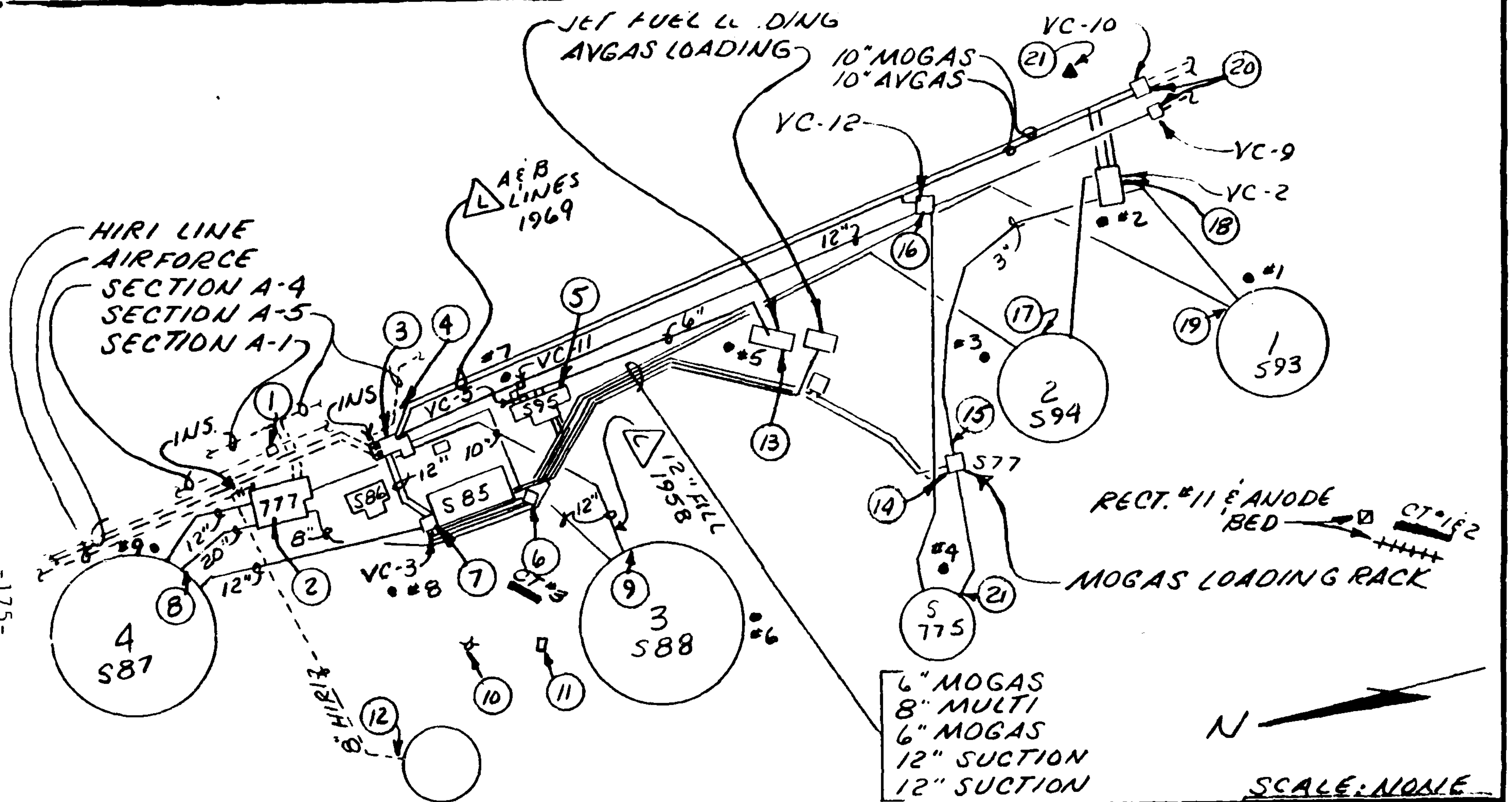
Negative Connection: Existing Rectifier #11.

Rectifier D.C. Output: 33 volts - 24 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC, E of S777			
	8" JP-5 Line to S777	- 765	- 960	195
2.	Bldg. S777			
	10" HIRI Line			
	HIRI side of Ins.	- 940	- 980	40
	Navy side of Ins.	- 715	- 780	65
	12" JP-4 Line	- 715	- 755	40
	10" JP-5 Line	- 715	- 755	40
	16" JP-5 Line			
	Above ground side of Ins.	- 720	- 755	35
	Below ground side of Ins.	- 715	- 755	40
	18" JP-4 Line			
	Above ground side of Ins.	- 720	- 755	35
	Below ground side of Ins.	- 775	- 820	45
	12" Line B	- 690	- 690	0
	12" Line A	- 720	- 750	30
3.	VC-1 & VC-1A			
	10" Mogas Line			
	Ewa side of Ins.	- 720	- 800	80
	Navy side of Ins.	- 800	- 890	90
	10" Avgas Line			
	Ewa side of Ins.	- 770	- 800	30
	Navy side of Ins.	- 800	- 890	90
	12" Mogas Line to VC-3	- 800	- 890	90
	12" Avgas line to VC-3	- 800	- 890	90
	16" JP-4 to Victor Docks	- 800	- 890	90
	10" Mogas to VC-9 & VC-10	- 800	- 890	90
	10" Avgas to VC-9 & VC-10	- 800	- 890	90

	12" JP-4 to VC-11	- 800	- 890	90
	10" Avgas to S85	- 800	- 890	90
	12" Fill Line to Tank S88	- 800	- 890	90
4.	FH. #45 E of VC-1 & VC-1A	- 555	- 555	0
5.	Bldg. S95			
	All Lines	- 800	-1120	320
6.	VC-4			
	All Lines	- 800	-1240	390
7.	VC-3			
	All Lines	- 900	-1400	500
8.	Tank #4 (S87)			
	At Tank	- 760	- 895	135
	12" JP-4 line (valve dropped at tank)	- 775	- 895	120
	20" Suction & Fill Line (valve dropped at tank)	- 730	- 855	125
	12" JP-4 from VC-3 (valve dropped at tank)	- 785	- 950	165
9.	Tank #3 (S88)			
	At Tank	- 880	-1340	460
	12" Suction	- 880	-1340	460
	12" Fill Line	- 940	-1220	280
10.	FH. (Foam Line) between Tanks #3 & #4	- 510	-1540	1030
11.	Separator, 2" Line	- 980	-1140	160
12.	HIRI Tank, SW of Tank #4	-1175	-1375	200
13.	Fuel Loading Rack			
	Avgas Line	- 780	- 860	80
	Mogas Line	- 780	- 860	80
14.	Bldg. S776			
	3" Ballast Line to VC-2	-1120	-1180	60
	3" Ballast line to Loading Rack	-1120	-1180	60
15.	6" Water Line, 10' N of Bldg. S776	- 920	-1040	120
	6" AFFF Line, N of Bldg. S776	- 780	- 860	80
	8" M.P. Line N of Bldg. S776	-1000	-1100	100
16.	VC-12			
	All Lines	- 950	-1010	60
17.	Tank #2 (S94)			

	At Tank	- 990	-1050	60
	12" Suction Line	- 990	-1050	60
	12" Fill Line	- 935	- 995	60
18.	Bldg. S98			
	All Lines	- 950	-1010	60
19.	Tank #1 (S93)			
	At Tank	-1040	-1100	60
	12" Suction Line	-1040	-1100	60
	12" Fill Line	- 940	- 985	45
20.	VC-9 & VC-10	- 950	- 995	45
21.	Existing test station, E side of Lehua Ave. & SE of VC-12			
	Navy Side	- 940	-1000	60
	Foreign Line Side	- 920	- 960	40
22.	Tank B-1 (S775)			
	At Tank	-1020	-1170	150
	12" Fill Line	-1070	-1170	100
	3" Suction Line	-1180	-1190	10



SCALE: NONE

LEGEND

- ● #1 — SOIL RESISTIVITY LOCATION
- (1)→ — PIPE-TO-SOIL POTENTIAL LOCATION
- ▬ CT#1 — CURRENT TEST LOCATION
- ——— — UNDERGROUND POL LINE
- INS. ‖ — INSULATING FLANGE (3)
- △L→ — LEAK LOCATION, POL LINE
- ⊠ — EXISTING RECTIFIER
- ┼┼┼ — EXISTING ANODE BED
- ▲ — EXISTING TEST STATION OR TEST BOX

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: A-5
DRAWN: R. E. F.	DATE: 2-12-82
APPROVED: [signature]	NUMBER: 6500

AD-A119 019 PACIFIC CORROSION RESEARCH INC HUNTINGTON BEACH CA F/G 13/8

A-E SERVICES TO PERFORM A CATHODIC PROTECTION SURVEY OF THE BUL--ETC(U)

JUN 82 N62742-81-C-0006

UNCLASSIFIED NL

3 OF 5

AD A

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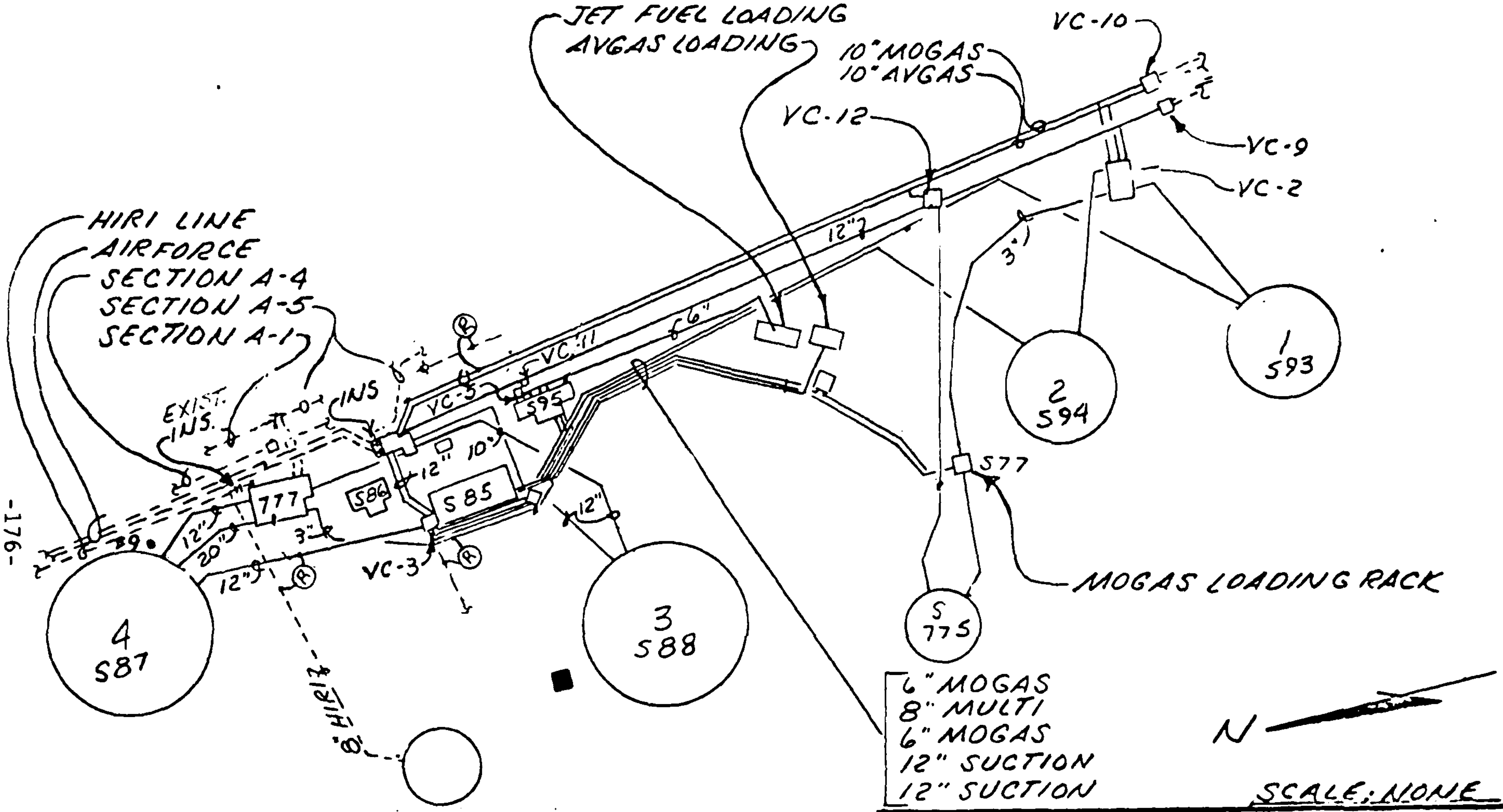


L E G E N D

® INSTALL RESISTANCE BOND STATION

■ INSTALL NEW OIL COOLED RECTIFIER AND INSTALL HIGH SILICON IRON TUBULAR ANODES

PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA

BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII

CORROSION SURVEY

PROPOSED C.P. SYS.	SECTION: A-5
DRAWN: R.E.F.	DATE: 2-12-82
APPROVED: [illegible]	NUMBER: 6500-A

SECTION B-1

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE LINES FROM VC-1 TO THE HOTEL PIER

SECTION B-1

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE LINES FROM VC-1 TO THE HOTEL PIER

SECTION B-1

SUMMARY

1. Conclusions:

Based on the field data obtained, the following results were observed:

A. The soil resistivity measurements obtained in the field show a non-uniform environment. Where pipelines traverse areas of varying resistivity, corrosion will take place in the area of the lower resistivity. We would expect corrosion attack to occur on the underground metallic structure, particularly in the areas of the low soil resistivity.

B. The POL lines of this section are not receiving full cathodic protection.

C. The POL lines are electrically continuous with each other from VC-1 to VC-3.

D. No insulators were found to be installed on the POL lines.

E. Approximately 33,520 sq. ft. of coated steel POL lines and 21, 000 sq. ft. of X-Tru-Coated steel POL lines are to be considered for cathodic protection in Section B-1. Approximately 60 amperes D.C. will be required to accomplish this achievement.

F. During this survey, interference was found on the HIRI line and the Base owned 24" cast iron water line, west of the POL lines, between VC-1 and VC-2. This interference is a result of the following:

(1) The installed anode bed of Rectifier #8 is too close to the HIRI and cast iron water lines.

(2) Rectifier #8 was found to be operating at a high D.C. current output.

G. Rectifier #8 was found to be operating at 18 volts and 140 amperes, during this survey. The protective current has been provided by two large diesel engine blocks which were installed 20 feet deep and approximately 20 feet apart in a coffee ground backfill. This amount

of protective current to the protected lines has been reduced to 50% of its effectiveness because of current bucking. This is the result of engine blocks being installed in close proximity to each other.

H. Visual inspection of the POL lines in the concrete trench and in the concrete valve pits on Hotel Pier indicated that the coating of these pipelines has been damaged in certain areas directly under the open spacing between the concrete covers. There has been pitting, rusting and oxidation in these areas. The POL lines were inspected in the valve pits and found to be bare steel with slight rusting and oxidation occuring on the surface. There were leaks from most control valves and appurtances above ground in the concrete valve pits.

I. Approximately three years ago, a completely new cathodic protection system, for all the new fuel lines which were replaced in this section and others in close proximity, was designed and contracted to be installed.

The drawings and specifications clearly show the anodes, their locations and the test points and insulator requirements. However, during construction, either by permission or by oversight, the contractor did not install the insulators or the test stations and deleted some anodes which were called for on the plans and specifications.

The A&E was not consulted about this change and as a result, the thousands of dollars spent for a new cathodic protection system has been wasted by changes which destroyed the effectiveness of the new cathodic protection system.

2. Recommendations:

A. As we mentioned above, interference was found on the HIRI line and the Base owned 24" cast iron water main. To minimize the interference problem, it is necessary to replace the existing rectifier (30 v -50 a.) with a small D.C. capacity rectifier and to install two additional small D.C. capacity rectifiers. The existing anode bed, of Rectifier #8, should be replaced with fourteen (14) 4"x40" graphite anodes. These anodes should be installed in the area east of the POL lines and north of Building 550. The existing rectifier should be replaced with a new

oil cooled rectifier. It is recommended that the first additional anode bed consisting of one new rectifier and twelve 4½"x60" high silicon iron anodes be installed south of the POL lines between VC-2 and VC-3. The second additional anode bed consisting of one new rectifier and fourteen (14) 4"x40" graphite anodes be installed east of the POL lines and south of Building 530.

B. To eliminate the interference to the 8" HIRI line and the Base owned 24" cast iron water main, it will be necessary that the 24" cast iron water main with mechanical joints be bonded across each joint between VC-1 and VC-2.

C. All above ground POL lines should be isolated from the underground POL lines at Hotel Pier, preventing short circuiting between the POL lines and reinforcing steel.

D. The damaged coating of the POL lines in the concrete trench at the Hotel Pier should be repaired by re-coating the lines in the damaged areas with a bitumastic, by the glove method.

It is recommended that the bare POL lines in the concrete valve pits be coated and wrapped. It is also recommended that the valve leaks in the valve pits be repaired.

E. It is important that someone at Pearl Harbor be designated to control all changes in construction including repairs, to preclude permitting work which destroys the effectiveness of existing or proposed cathodic protection systems. Inspection of new work should also be controlled to preclude deviations to plans and specifications and the resulting destruction of the effectiveness of new and existing systems.

SECTION B-1

POL LINES INSIDE THE PEARL HARBOR COMPLEX INCLUDING THE LINES FROM VC-1 TO HOTEL PIER

1. Description.

A. Lines to be Protected:

(1) From VC-1 to VC-2: Underground Lines

a. 32" DFM Lines	-	Coated Steel
b. 16" DFM Line	-	Steel with X-Tru-Coat
c. 18" JP-5 Line	-	Steel with X-Tru-Coat
d. 12" Ballast Line	-	Fiberglass
e. 12" JP-5 Line	-	Coated Steel
f. 4" Drain Line	-	Fiberglass

(2) From VC-2 to VC-3: Underground Lines

a. 32" DFM Line	-	Coated Steel
b. 16" DFM Line	-	Steel with X-Tru-Coat
c. 18" JP-5 Line	-	Steel with X-Tru-Coat
d. 12" Ballast Line	-	Coated Steel
e. 12" JP-5 Line	-	Coated Steel
f. 6" Drain Line	-	Coated Steel

(3) From VC-3 to Hotel Pier: The following lines are underground between VC-3 and Hotel Pier. The lines on Hotel Pier are in a concrete trench and/or in air, supported under the concrete pier.

a. 2 - 22" DFM Lines	-	Coated Steel
b. 2 - 12" JP-5 Lines	-	Coated Steel
c. 12" NSFO Line	-	Coated Steel
d. 12" DFM Line	-	Coated Steel
e. 12" OW Line	-	Coated Steel

f. 12" Ballast Line - Coated Steel

g. 8" Defuel Line - Coated Steel

B. Existing Cathodic Protection System:

This section of lines are partially protected by an impressed current and a sacrificial anode C.P. System.

(1) Impressed Current C.P. System. This system consists of one 30 volt and 150 ampere oil cooled rectifier and two diesel engine blocks as anodes.

a. Rectifier Location: Rectifier #8 is located on the west side of VC-2.

b. Rectifier Unit: Mfg. - Brance Kraghy Co., Inc.
Serial No. - 753122
D.C. Capacity - 30 V, 150 A
Operating at - Tap setting 4-7
D.C. Output - 18 V, 140 A
Date Recorded - August 8, 1981

c. Anode Bed Location: Two diesel engine blocks were installed approximately 200' south of VC02 and 50' west of the fuel lines.

(2) Sacrificial Anode Cathodic Protection System. This system consists of three test boxes and thirty 32 lb. prepackaged magnesium anodes.

a. Test Box #1 - This test box is located 102' north of VC-1. Eight 32 lb. prepackaged magnesium anodes were installed in 1978. Four test leads were found to be broken and/or disconnected from the pipes in this test box.

b. Test Box #2 - This test box is located 200' south of VC-2. Fifteen 32 lb. prepackaged magnesium anodes were installed in 1978.

c. Test Box #3 - This test box is located 185' east of VC-3. Seven 4" x 4" x 36" 160 lb. zinc anodes were installed in 1978. The anode bed open circuit potential and current output measurements of each anode bed were obtained at each test box.

The results of these measurements are shown in Table XXII under Section E-2.

2. Field Work and Evaluation of Data.

A. Soil Resistivity Measurements: A total of thirteen sets of measurements were obtained at representative locations as shown in Table No. VI-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	20	Severe
Medium	2,000 - 10,000	60	Moderate
High	10,000 - 30,000	20	Slight, unless other factors are pronounced
Very High	Above - 30,000	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on all underground metallic structures. Twenty percent of the measurements obtained were in the severe category and sixty percent were in the medium category.

B. "As Found" Pipe-to-Soil Potentials: "As Found" pipe-to-soil potentials were obtained at each valve chamber and each test box. The results of these measurements indicate that the POL lines are not at a protective level, with the exception of the POL lines south of VC-2 and a portion of the POL lines east of VC-3. The HIRI line from VC-1 to north of the base is cathodically protected by HIRI. The results of these measurements are shown in Table No. VI-B.

C. Current Tests: Three current tests were conducted on this section of POL lines. Pipe-to-soil potentials were obtained at the same locations as "as found" potentials with the test rectifier "off" and "on".

(1) Current Test No. 1 - This test was conducted in the area adjacent to Test Box #1. Sixteen steel rods were installed 30' northeast of Test Box #1 as a temporary anode bed. A test rectifier was used for D.C. power source. The current used for this test was 30 amperes D.C. with a negative from the rectifier connected to the test lead at Test Box #1. The results of this test is shown in Table No. VI-C.

(2) Current Test No. 2 - This test was conducted in the lawn area near Test Box #3. The seven existing anodes (zinc) were used as a temporary anode bed. The negative wire from the test rectifier was connected to the test

lead at Test Box #3. A current flow of 28 amperes D.C. was used for this test. The results of this test may be found in Table No. VI-D.

(3) Current Test No. 3 - This test was conducted as a continuity test. Pipe-to-soil potentials were obtained at representative locations of Section B-1 and at the locations adjacent to Section B-1. Pipe-to-soil potentials were obtained while the existing Rectifier #8 was turned "off" and "on". The results of this test may be found in Table No. VI-E.

Based on the data obtained from these current tests, the following results were observed:

a. The POL lines of Section B-1 are electrically continuous with the POL lines of B-2, B-4, B-5 and B-6.

b. Rectifier #8 does not provide adequate protective current for these sections.

c. The current requirements for Section B-1 will be high.

d. Interference was found on the Base owned 24" cast iron water main and the 8" HIRI line from the existing anode bed (Rectifier #8) between VC-1 and VC-2. See reading numbers 12 and 13, Table No. VI-C.

e. No insulators were found to be installed on the POL lines of Section B-1.

D. Inspection of Pipelines:

Inspection of the POL lines in the concrete trench on Hotel Pier were made at two locations. Concrete covers at these two locations were lifted by Base personnel with assistance

from Mr. Edwin Katada. Visual inspection was also made on the POL lines in each concrete valve pit.

(1) Inspection #1 - This inspection was made of the POL lines 16' east of Valve-29.

a. 12" JP-5 Line - This line is coated with coal tar and fiberglass mesh. A 7" wide piece of coating was found missing from the top and sides of the pipe directly under the open spacing between the concrete covers. Heavy pitting was found in this area. One large pit was ½" in diameter and 0.11" in depth.

b. 22" DFM Line - The coating for this pipeline is the same as for the 12" JP-5 line. A 5" wide piece of coating was found missing from the top and sides of the pipe directly under the open spacing between the concrete covers. Pitting and rusting was noted on the pipe. The depth of the largest pit is 0.07".

c. 12" DFM Line - The coating for this pipeline is the same as for the 12" JP-5 line. A 4" wide piece of coating was missing from the top and sides of the pipe directly under the open spacing between the concrete covers. Pitting and rusting was noted on the pipe. The average depth of the pitting is 0.025" in depth.

(2) Inspection #2 - This inspection was made over the POL lines 6" west of Valve-23.

a. 12" JP-5 Line - A coating crack was found on the

pipe. The coating can be considered in only fir condition.

b. <u>22" DFM Line</u> - A 4" diameter coating crack was found on the top of the 22" DFM line. There has been slight pitting and oxidation on the pipe surface.

c. <u>12" DFM Line</u> - The coating of pipeline was checked and found in fair condition. Very little corrosion and pitting was noted on this line.

Visual inspection of the POL lines in the valve pit indicates that the pipelines are bare steel with slight rusting and oxidation occurring on the surface. Also, fuel leaks were found at most control valves above ground in the valve pits.

E. <u>Excavations</u>:

Two excavations were made over the POL lines during this survey:

(1) <u>Excavation #1</u> - This excavation was over the POL lines, 5' east of VC-3. The POL lines were excavated and excavated and exposed with a backhoe by Base personnel. The POL lines were installed 8' deep and were below the water table. Therefore, no pipeline inspection was made of this location. Pipe-to-soil potentials were taken on these pipes after these lines were excavated. The results indicated that no insulator was installed on the 16" DFM and the 10" JP-5 pipelines. These two lines were found to be electrically continuous with the other POL lines in VC-3. No insulating

flange sets were installed as called for in the construction documents.

(2) Excavation #2 - This excavation was made over the POL lines 15' south of Test Box #1 and approximately 85' north of VC-1. The 22" DFM line is coated with coal tar enamel. The 12" Ballast line is fiberglass. The 18" DFM and 16" JP-5 lines are steel with X-Tru-Coat coating. The coating of these pipelines appeared in good condition. No insulating flange sets were found as called for in the construction documents.

F. Leak History:

The leak history was discussed with Mr. John Kimi, Mr. Edwin Katada and Mr. Albert Wong of the Base Fuel Department. Leaks on the POL lines were located and are shown on PCR Drawing No. 6477. We were advised by Mr. Art Lundberger, of PWC, NSC, that 90% of the water main in Section B-1 is cast iron pipe with mechanical joints. There have been no leaks reported on the cast iron water main in the past.

3. Conclusions.

Based on the field data obtained, the following results were observed:

A. The results of soil resistivity measurements indicate that 20% of the readings are in the severe category and 60% are in the moderate category. The measurements obtained in the field show a non-uniform environment. Where pipelines traverse areas of varying resistivity, corrosion will take

place in the area of the lower resistivity. We would expect corrosion attack to occur on the underground metallic structure, particularly in the areas of low soil resistivity.

B. The POL lines of this section are not receiving full cathodic protection.

C. The POL lines are electrically continuous to each other from VC-1 to VC-3.

D. No insulators were found to be installed on the POL lines.

E. The results of the current tests conducted indicated that the current demand for this section will be high. Approximately 33,520 sq. ft. of coated steel POL lines and 21,000 sq. ft. of X-Tru-Coated steel POL lines are to be considered for cathodic protection in Section B-1. Approximately 60 amperes D.C. will be required to accomplish this achievement.

F. During this survey, interference was found on the HIRI line and the Base owned 24" cast iron water line, west of the POL lines, between VC-1 and VC-2. This interference is a result of the following:

  (1) The installed anode bed of Rectifier #8 is too close to the HIRI and cast iron water lines.

  (2) Rectifier #8 was found to be operating at a high D.C. output.

G. Rectifier #8 was found to be operating at 18 volts and 140 amperes during this survey. The protective current has been provided by two large diesel engine blocks which were installed 20' deept and approximately 20' apart in a coffee ground backfill. This amount of protective current to the protected lines has been reduced to 50% of its effective-

ness because of current bucking. This is the result of engine blocks being installed in close proximity to each other.

H. Visual inspection of the POL lines in the concrete trench and in the concrete valve pits on Hotel Pier indicated that the coating of these pipelines has been damaged in certain areas directly under the open spacing between the concrete covers. There has been pitting, rusting and oxidation in these areas. The POL lines were inspected in the valve pits and found to be bare steel with slight rusting and oxidation occurring on the surface. There were leaks from most control valves and appurtances above ground in the concrete valve pits.

I. Approximately three years ago, a completely new cathodic protection system, for all the new fuel lines which were replaced in this section and others inclose proximity, was designed and contracted to be installed.
The drawings and specifications clearly show the anodes, their locations and the test points and insulator requirements. However, during the construction, either by permission or by oversight, the contractor did not install the insulators or the test stations and deleted some anodes which were called for on the plans and specifications.
The A & E was not consulted about this change and as a result, the thousands of dollars spent for a new cathodic protection system has been wasted by changes which destroyed the effectiveness of the new cathodic protection system.

4. <u>Recommendations</u>:

A. The current tests conducted indicate that the current demand for the underground metallic structures will require two additional anode beds to provide protection for Section B-1. It is recommended that the first additonal anode bed consisting of one new rectifier and twelve 4½"x60" high silicon iron anodes be installed south of the POL lines between VC-2 and VC-3. The second additional anode bed consisting of one new rectifier and fourteen 4"x40" graphite anodes be installed east of the POL lines and south of Building 530. An anode watering system should be installed for this anode bed.

B. The existing anode bed, of Rectifier #8, should be replaced with fourteen 4"x40" graphite anodes. These anodes should be installed in the area east of the POL lines and north of Building 550. The existing rectifier should be replaced with a new oil cooled rectifier. It is recommended that an anode watering system be installed along with this anode bed.

C. To eliminate the interference to the 8" HIRI line and the Base owned 24" cast iron water main, it will be necessary that the 24" cast iron water main with mechanical joints be bonded across each joint between VC-1 and VC-2.

D. All above ground POL lines should be isolated from the underground POL lines at Hotel Pier, preventing short circuiting between the POL lines from the re-inforcing steel.

E. The damaged coating of the POL lines in the concrete trench at the Hotel Pier should be repaired by re-coating the lines in the damaged areas with bitumastic, by the glove method.

It is recommended that the bare POL lines in the concrete valve pits be coated and wrapped. It is also recommended that the valve leaks in the valve pits be repaired.

F. It is important that someone at Pearl Harbor be designated to control all changes in construction including repairs, to preclude permitting work which destroys the effectiveness of existing or proposed cathodic protection systems. Inspection of new work should also be controlled to preclude deviations to plans and specifications and the resulting destruction of the effectiveness of new and existing systems.

NOTE: The locations of pipe-to-soil potentials, soil resistivities current tests and the existing C.P. systems are shown on PCR Drawing No. 6477.

The recommended C.P. system of Section B-1 is shown on PCR Drawing No. 6477-A.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION B-1

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
OIL COOLED RECTIFIERS	3	ea	2700.00	8100.00	600.00	1800.00	3300.00	9900.00
4½"x60" HI SI FE ANODES	12	ea	720.00	8640.00	150.00	1800.00	870.00	10440.00
4'x40' GRAPHITE ANODES	28	ea	210.00	5880.00	150.00	4200.00	360.00	10080.00
#2 HMP STRANDED COPPER CABLE	1400	ft	1.50	2100.00	0.15	210.00	1.65	2310.00
COAL COKE BREEZE	12000	lb	0.30	3600.00	0.08	900.00	0.38	4500.00
1" PVC CLASS 200, PLASTIC PIPE	2200	ft	0.75	1650.00	0.15	330.00	0.90	1980.00
CONCRETE TEST BOXES/CAST IRON LIDS	2	ea	45.00	90.00	75.00	150.00	120.00	240.00
SPLIT BOLTS	50	ea	1.50	75.00	7.50	375.00	9.00	450.00
BUTYL TAPE	6	rl	37.50	225.00	45.00	270.00	82.50	495.00
RUBBER TAPE	12	rl	4.50	54.00	7.50	90.00	12.00	144.00
PLASTIC TAPE	12	rl	4.50	54.00	7.50	90.00	12.00	144.00
COAL ENAMEL (1 GALLON CAN)	2	ea	22.50	45.00	45.00	90.00	67.50	135.00
TERRA TAPE	1200	ft	0.22	264.00	0.08	96.00	0.30	360.00
CONCRETE PADS	2	ea	150.00	300.00	300.00	600.00	450.00	900.00
RESISTANCE BOND STATION	4	ea	150.00	600.00	150.00	600.00	300.00	1200.00
BONDING OF CAST IRON PIPE	1800	ft	3.00	5400.00	10.50	18900.00	13.50	24300.00
INSULATORS	9	ea	45.00	405.00	75.00	675.00	120.00	1080.00

S/N 0105-LF-010-1335
★ G.P.O.: 1979-689-016/4302

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 2 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM CORROSION SUSPENSION SURVEY, SECTION B-1

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
INSULATORS	9	ea	45.00	405.00	75.00	675.00	120.00	1080.00
ALUMINO-THERMIC WELDS	20	ea	3.00	60.00	37.50	750.00	40.50	810.00
TRENCH	1200	ft	-	-	4.50	5400.00	4.50	5400.00
HOSE CONNECTION ADAPTER	2	ea	7.50	15.00	7.50	15.00	15.00	30.00
SUBTOTAL				37962.00		38016.00		75978.00
10% MISC. MATERIALS & LABOR				3796.00		3801.00		7597.00
SUBTOTAL				41758.00		41817.00		83575.00
30% CONSTRUCTION PROFIT				12527.40		12545.10		25072.50
TOTAL				54285.40		54362.10		108647.50

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

SECTION B-1

SOIL RESISTIVITIES

TABLE NO. VI-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	East of VC-1	10000	360	200
2.	NW of S768 Tank	9000	14000	10400
3.	W of Bldg. 530, W side of pipeline	10000	8800	12800
4.	200' N of Rdg. 3, W side of pipeline	7000	7100	10000
5.	W of SW corner of Bldg. 550 W side of pipeline	7000	11000	12600
6.	NW corner of Bldg. 550 E side of pipeline	14000	5400	2200
7.	200' N of Rdg. #6, E side of pipeline	3500	4000	3000
8.	200' N of Rdg. #7, E side of pipeline	3450	3600	2600
9.	W of VC-2, S of pipeline	2500	4200	2200
10.	200' W of Rdg. #9, S side of pipeline	13500	12000	7400
11.	200' W of Rdg. #10, S side of pipeline	25500	1500	7200
12.	200' W of Rdg. #11, S side of pipeline	1150	480	320
13.	N of VC-3	5000	2000	200

SECTION B-1

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. VI-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	VC-1	
	6" Multi.	
	HIRI side of Ins.	- 840
	Navy side of Ins.	- 640
	16" DFM for Pumphouse 59	- 640
	18" JP-5 from Pumphouse 59	- 640
	18" DFM from Pumphouse 59	- 640
	18" DFM to VC-7	- 640
	12" NSFO to VC-7	- 640
	6" JP-5 to Loading Rack	- 640
	4" Drain to VC-12	- 620
	12" NSFO to Merry Pt.	- 640
	18" DFM to Merry Pt.	- 640
	4" Drain & 12" Ballast are fiberglass.	
2.	Hose bibb S side	- 500
3.	Test Box #1, 101' 6" N of VC-1	- 720
4.	Test Box #2, E of VC-3	-1680
5.	VC-2	
	16" DFM to VC-1	-1100
	18" JP-5 to VC-1	-1090
	32" DFM to VC-1	-1090
	8 " DFM (abandoned)	-1090
	16" DFM to VC-3	-1090
	18" JP-5 to VC-3	-1090
	32" DFM to VC-3	-1090
	4" Drain & 12" Ballast are fiberglass.	
6.	6" Multi HIRI Line at Bridge, NW of VC-2	-1280
7.	Water Line W side of Bridge NW of VC-2	- 625
8.	Test Box #3, 136' 8" NW of Bldg. 489, SE of Telephone Booth	-1060
9.	F.H. #541, E of VC-3	- 590
10.	VC-3	
	12" JP-5 to Red Hill Tunnel	- 825
	16" DFM to VC-2	- 825

	18" JP-5 to VC-2	- 825
	32" DFM to VC-2	- 825
	6" Drain to VC-2	- 870
	6" to small boat dock	- 825
	8" to small boat dock	- 825
	4" JP-5 to small boat dock	- 500
	6" Drain to Hotel Fuel Pier	- 825
	22" DFM to Hotel Fuel Pier	- 825
	12" JP-5 to Hotel Fuel Pier	- 825
	12" DFM to Hotel Fuel Pier	- 825
	8" DEFUEL to Hotel Fuel Pier	- 825
	4" Ballast and 12" Ballast are fiberglass.	
	8" DEFUEL to VC-4	- 825
	18" DFM to Hotel Fuel Pier	- 825
	10" NSFO to Hotel Fuel Pier	- 825
	12" NSFO to Hotel Fuel Pier	- 825
	22" DFM to Hotel Fuel Pier	- 825
	12" JP-5 to Hotel Fuel Pier	- 825
11.	Oily Waste Pump Station #1	- 300
12.	2" Water Line near Rdg. 10	- 500
13.	Fuel Storage Tanks near VC-3	- 715
14.	Hotel Fuel Pier	
	North side of Pier	
	22" DFM	- 780
	12" JP-5	- 780
	12" DFM	- 780
	South side of Pier	
	22" DFM	- 780
	12" JP-5	- 780
	12" DFM	- 780

SECTION B-1

CURRENT TEST NO. 1

TABLE NO. VI-C

Location:	Test Box #1 - North of VC-1
Anodes used for current test:	Sixteen steel rods as temporary anodes and the existing 32 lb. magnesium anodes at the test box.
Negative Connection:	To existing test lead in Test Box #1.
Rectifier D.C. Output:	45 volts - 30 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC-7			
	18" DFM to VC-5	- 660	- 700	40
	12" NSFO to VC-5	- 660	- 700	40
	6" DFM to Diesel Purification Plant	- 660	- 700	40
	10" DFM to Diesel Purification Plant	- 660	- 700	40
	12" NSFO to VC-1	- 660	- 700	40
	18" DFM to VC-1	- 660	- 700	40
	8" DFM to Loading Rack	- 660	- 700	40
	6" DFM/NSFO to Loading Rack	- 660	- 700	40
2.	VC-1			
	6" Multi.			
	HIRI side of Ins.	- 840	- 840	0
	Navy side of Ins.	- 610	- 700	90
	16" DFM form Pumphouse 59	- 610	- 700	90
	18" JP-5 from Pumphouse 59	- 610	- 700	90
	18" DFM from Pumphouse 59	- 610	- 700	90
	12" NSFO to VC-7	- 610	- 700	90
	18" DFM to VC-7	- 610	- 700	90
	6" JP-5 to Loading Rack	- 610	- 700	90
	4" Drain to VC-12	- 610	- 700	90
	12" NSFO to Merry Pt.	- 610	- 700	90
	18" DFM to Merry Pt.	- 610	- 700	90
3.	Hose bibb S side	- 490	- 485	- 5*
4.	Test Box #1, N of VC-1	- 790	-1140	350
5.	Tank S-768	- 780	-1080	300

6.	Tank L-2	- 640	-1160	520
7.	Test Box #2, S of Halawa Gate	-1690	-1730	40
8.	VC-2			
	16" DFM to VC-1	- 960	- 990	30
	18" JP-5 to VC-1	- 960	- 990	30
	32" DFM to VC-1	- 960	- 990	30
	8" DFM (abandoned)	- 960	- 990	30
	16" DFM to VC-3	- 960	- 990	30
	18" JP-5 to VC-3	- 960	- 990	30
	32" DFM to VC-3	- 960	- 990	30
9.	8" HIRI line at Bridge	-1280	-1250	-30*
10.	24" water line at Bridge	- 625	- 620	- 5*
11.	Test Box #3, E of VC-3	-1080	-1100	20
12.	VC-3			
	12" JP-5 to Red Hill Tunnel	- 830	- 850	20
	16" DFM to VC-2	- 830	- 850	20
	18" JP-5 to VC-2	- 830	- 850	20
	32" DFM to VC-2	- 830	- 850	20
	6" Drain to VC-2	- 830	- 850	20
	6" to small boat dock	- 500	- 505	5
	8" to small boat dock	- 830	- 850	20
	4" JP-5 to small boat dock	- 830	- 850	20
	6" Drain to Hotel Fuel Pier	- 830	- 850	20
	22" DFM to Hotel Fuel Pier	- 830	- 850	20
	12" JP-5 to Hotel Fuel Pier	- 830	- 850	20
	12" DFM to Hotel Fuel Pier	- 830	- 850	20
	8" Defuel to Hotel Fuel Pier	- 830	- 850	20
	8" Defuel to VC-4	- 830	- 850	20
	18" DFM to VC-4	- 830	- 850	20
	10" NSFO to VC-4	- 830	- 850	20
	12" NSFO to Hotel Fuel Pier	- 830	- 850	20
	22" DFM to Hotel Fuel Pier	- 830	- 850	20
13.	VC-4			
	18" DFM to VC-3	- 830	- 845	15
	10" NSFO to VC-3	- 830	- 845	15
	8" Defuel to VC-3	- 830	- 845	15
	14" Water	- 550	- 550	0
	8" Defuel to VC-38	- 830	- 845	15
	12" DFM to VC-5	- 830	- 845	15
	8 " DFM to VC-5	- 830	- 845	15
	8" DFM to VC-6	- 830	- 845	15
	12" DFM to VC-6	- 830	- 845	15

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION B-1

CURRENT TEST NO. 2

TABLE NO. VI-D

Location:	Test Box #3, East of VC-3
Anodes used for current test:	Seven existing 150 lb. zinc anodes.
Negative Connection:	To existing test lead in test box.
Rectifier D.C. Output:	5.5 volts - 28 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC-7			
	18" DFM to VC-5	- 645	- 655	10
	12" NSFO to VC-5	- 645	- 655	10
	6" DFM to Diesel Purification Plant	- 645	- 655	10
	10" DFM to Diesel Purification Plant	- 645	- 655	10
	12" NSFO to VC-1	- 645	- 655	10
	18" DFM to VC-1	- 645	- 655	10
	8" DFM to Loading Rack	- 645	- 655	10
	6" DFM/NSFO to Loading Rack	- 645	- 655	10
2.	VC-1			
	6" Multi.			
	HIRI side of Ins.	- 840	- 835	- 5*
	Navy side of Ins.	- 620	- 635	15
	16" DFM from Pumphouse 59	- 620	- 635	15
	18" JP-5 from Pumphouse 59	- 620	- 635	15
	18" DFM from Pumphouse 59	- 620	- 635	15
	18" DFM to VC-7	- 620	- 635	15
	12" NSFO to VC-7	- 620	- 635	15
	6" JP-5 to Loading Rack	- 620	- 635	15
	4" Drain to VC-12	- 620	- 635	15
	12" NSFO to Merry Pt.	- 620	- 635	15
	18" DFM to Merry Pt.	- 620	- 635	15
3.	Hose bibb, S of VC-1	- 500	- 505	5
4.	Test Box N of VC-1	- 790	- 820	30
5.	Test Box S of Halawa Gate	-1680	-1720	40

6.	VC-2			
	16" DFM to VC-1	- 980	-1000	20
	18" JP-5 to VC-1	- 980	-1000	20
	32" DFM to VC-1	- 980	-1000	20
	8" DFM (abandoned)	- 980	-1000	20
	16" DFM to VC03	- 980	-1000	20
	18" JP-5 to VC-3	- 980	-1000	20
	32" DFM to VC-3	- 980	-1000	20
7.	8" Multi. HIRI line at bridge NW of VC-2	-1280	-1270	-10*
8.	Water Line W side of Bridge, NW of VC-2	- 625	- 630	5
9.	Test Box #3, 136'8" NW of Bldg. 489, S of east telephone booth	-1080	-1350	270
10.	F.H. #541, E of VC-3	- 590	- 610	20
11.	VC-3			
	12" JP-5 to Red Hill Tunnel	- 840	- 865	25
	16" DFM to VC-2	- 840	- 865	25
	18" JP-5 to VC-2	- 840	- 865	25
	32" DFM to VC-2	- 840	- 865	25
	6" Drain to VC-2	- 840	- 865	25
	6" to small boat dock	- 840	- 865	25
	8" to small boat dock	- 840	- 865	25
	6" Drain to Hotel Fuel Pier	- 840	- 865	25
	22" DFM to Hotel Fuel Pier	- 840	- 865	25
	12" JP-5 to Hotel Fuel Pier	- 840	- 865	25
	12" DFM to Hotel Fuel Pier	- 840	- 865	25
	8" Defuel to VC-4	- 840	- 865	25
	18" DFM to VC-4	- 840	- 865	25
	10" NSFO to VC-4	- 840	- 865	25
	12" NSFO to Hotel Fuel Pier	- 840	- 865	25
	22" DFM to Hotel Fuel Pier	- 840	- 865	25
	12" JP-5 to Hotel Fuel Pier	- 840	- 865	25
12.	2" water line near Rdg. #10			
13.	Fuel Stoarage Tanks near VC-3	- 715	- 720	5
14.	Hotel Fuel Pier			
	North side of Pier			
	22" DFM	- 780	- 805	25

12" JP-5	- 780	- 805	25
12" DFM	- 780	- 805	25
South side of Pier			
22" DFM	- 780	- 805	25
12" JP-5	- 780	- 805	25
12" DFM	- 780	- 805	25
15. VC-4			
18" DFM to VC-3	- 830	- 855	25
10" NSFO to VC-3	- 830	- 855	25
8" Defuel to VC-3	- 830	- 855	25
14" Water	- 550	- 540	-10*
5" Defuel to VC-38	- 830	- 855	25
8" DFM to VC-5	- 830	- 855	25
12" DFM to VC-5	- 830	- 855	25
8" DFM to VC-6	- 830	- 855	25
12" DFM to VC-6	- 830	- 855	25
16. Underground Tank N of VC-3	- 715	- 720	5
17. F.H. #541	- 590	- 610	20

*A minus indicates that pipe-to-soil potentials became less negative as a result of application of test current.

SECTION B-1

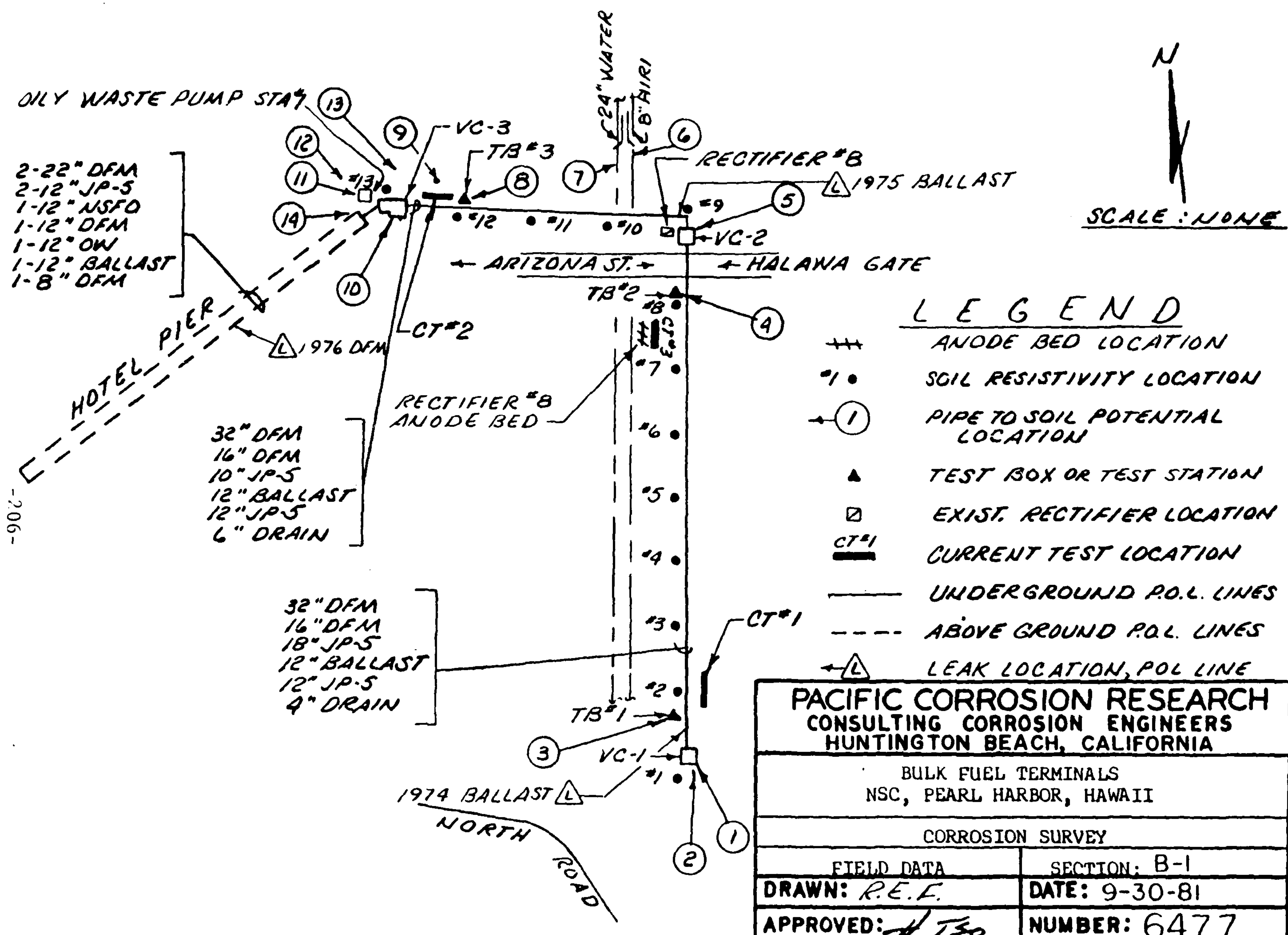
CONTINUITY TEST NO. 3

TABLE NO. VI-E

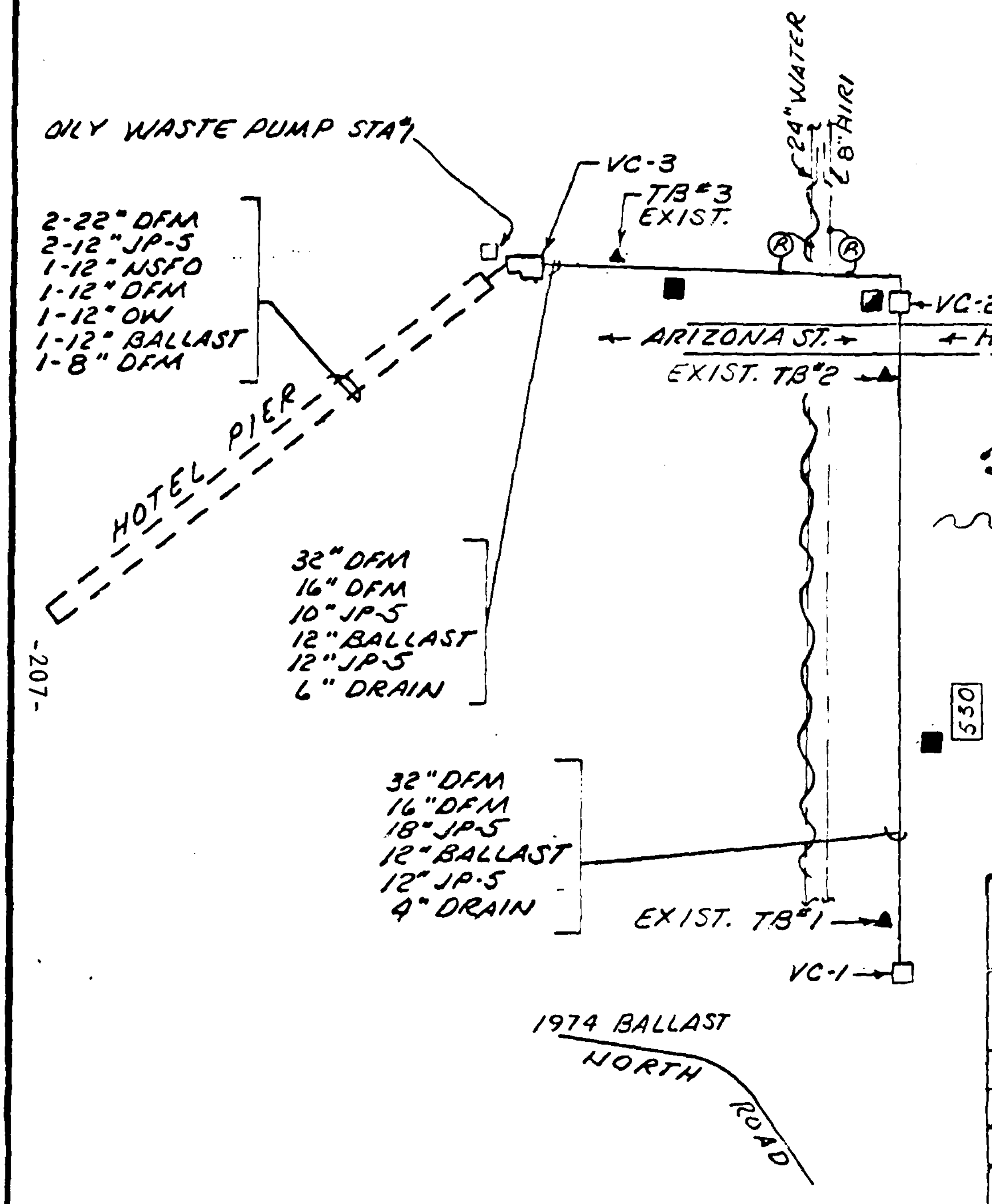
Location:	VC-2, existing Rectifier #8.
Anodes used for current test:	Two existing diesel engine blocks installed in waste coffee bean backfill.
Negative connection:	Existing.
Rectifier D.C. Output:	18 volts - 140 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC-1 HIRI line (Sec. B-1)	-1150	- 840	-310*
2.	Hose bibb, S of VC-1 (Sec. B-1)	- 520	- 500	- 20*
3.	Test Box N of VC-1 (Sec. B-1)	- 790	- 900	110
4.	Test Box S of Halawa Gate (Sec. B-1)	- 870	-1675	805
5.	VC-2 (Sec. B-1)			
	16" DFM to VC-1	- 785	-1090	305
	18" JP-5 to VC-1	- 785	-1090	305
	32" DFM to VC-1	- 785	-1090	305
	8" DFM (abandoned)	- 785	-1090	305
	16" DFM to VC-3	- 785	-1090	305
	18" JP-5 to VC-3	- 785	-1090	305
	32" DFM to VC-3	- 785	-1090	305
6.	22" Water line at bridge NW of VC-2	- 440	- 400	40
7.	Service Station W of Halawa (Sec. B-1)			
	Gate NE Tank	- 810	- 840	30
	Gate SW Tank	- 960	-1000	40
8.	VC-3, 32" Oil line (Sec. B-1)	- 810	- 940	130
9.	2" Water near VC-3 (Sec. B-1)	- 505	- 500	-5*
10.	VC-4 (Sec. B-2)			
	18" DFM	- 680	- 820	140
	10" NSFO	- 680	- 820	140
	14" C.I. Water	- 540	- 540	0

11.	VC-5 All Lines	- 610	- 680	70
12.	Test Box east of VC-3 (Sec. B-1)	-1060	-1060	0
13.	VC-7 (Sec. B-2) All Lines	- 595	- 650	55
14.	VC-6 (Sec. B-2) All Lines	- 715	- 805	90
15.	Test Box east of VC-6 (Sec. B-2)	- 715	- 800	85
16.	VC-38 Bldg. 60 (Sec. B-3) All Lines	- 570	- 590	20
17.	VC-19 (Sec. B-3) 8" DFM (abandoned) 12" DFM	- 350	- 425	75
18.	VC-8 (Sec. B-4)	- 630	- 680	50
19.	Test Box West of VC-5 (Sec. B-3)	- 635	- 720	85



PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: B-1
DRAWN: R.E.E.	DATE: 9-30-81
APPROVED: H. Tso	NUMBER: 6477



LEGEND

INSTALL RESISTANCE BOND STA.

CONTINUITY BOND CAST IRON WATER LINE ACROSS EACH JOINT.

INSTALL NEW OIL COOLED RECTIFIER AND INSTALL HIGH SILICON IRON TUBULAR ANODES OR GRAPHITE ANODES.

REPLACE EXIST. RECTIFIER #8 WITH A NEW OIL COOLED RECTIFIER AND INSTALL GRAPHITE ANODES.

PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA

BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII

CORROSION SURVEY

PROPOSED C.P. SYS.	SECTION: B-1
DRAWN: R.E.F.	DATE: 9-30-81
APPROVED: H. TSO	NUMBER: 6477-A

SECTION B-2

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING LINES FROM VC-1 TO KILO AND HOTEL PIERS

SECTION B-2

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING LINES FROM VC-1 TO KILO AND HOTEL PIERS

SECTION B-2

SUMMARY

1. Conclusions:

Based on the field data obtained, the following results were observed:

A. The soil environment in Section B-2 can be classified as an area of severe corrosion potential.

B. The POL lines in Section B-2 are not at a protective potential level will all potentials below -850 mv.

C. The POL lines are electrically continuous to each other from VC-3 to VC-1 and from VC-3 to Kilo Pier.

D. No insulators were found to be installed on the POL lines of Section B-2, as called for in the construction documents.

E. Approximately 24,410 sq. ft. of coated steel POL lines and 11,300 sq. ft. of X-Tru-Coated steel pipe are to be considered for cathodic protection. A protective current of 50 amperes will be required to provide a protective potential level.

F. During this survey, the 14" cast iron water main in VC-4 was found to be electrically discontinuous with the POL lines.

G. No interference on the POL lines and/or on the other lines were found during this survey.

H. Inspection of the DFM lines under Kilo Pier indicate the following:

(1) The coating of the POL lines can be considered to be in good condition. Only a small portion of coating was damaged and required repair.

(2) The two flanges of the 10" DFM lines at the west quay wall under K-6 and K-9 in the air were found to be severely corroded and rusted.

2. Recommendations:

A. Current tests conducted indicated that the current demand for the underground metallic structures will require one additional anode bed to provide protection for Section B-2. It is recommended that the additional anode bed consisting of one new oil cooled rectifier and fourteen (14) 4½" x 60" high silicon iron anodes be installed west of Building 482 and on the west side of Neosho Avenue.

B. The underground DFM lines should be isolated from the DFM lines under the Kilo Docks, preventing short circuit between the POL lines and the re-inforcing steel.

C. The damaged coating of the DFM lines under the Kilo Docks should be repaired by recoating the lines in the damaged areas with polymastic by the glove method.

SECTION B-2

POL LINES INSIDE THE PEARL HARBOR COMPLEX INCLUDING LINES FROM VC-1 TO KILO AND HOTEL PIERS

1. Description:

A. Lines to be Protected:

(1) From VC-1 to VC-4

a.	18" DFM line	-	Coated Steel
b.	10" NSFO line	-	Coated Steel

(2) From VC-7 to Truck Loading Rack

a.	6" DFM/NSFO line	-	Coated Steel
b.	8" DFM line	-	Coated Steel

(3) From VC-7 to VC-5

a.	18" DFM line	-	Coated Steel
b.	12" DFM line	-	Coated Steel

(4) From VC-4 to VC-6

a.	8" DFM line	-	Steel with X-Tru-Coat
b.	10" DFM line	-	Steel with X-Tru-Coat

(5) From VC-5 to VC-4

a.	18" DFM line	-	Coated Steel
b.	10" NSFO line	-	Coated Steel

(6) From VC-4 to VC-3 and Hotel Pier

a.	18" DFM line	-	Steel with X-Tru-Coat
b.	10" NSFO line	-	Steel with X-Tru-Coat
c.	8" Defuel line	-	Coated Steel

(7) From VC-6 to Kilo Docks

a.	10" DFM (reduced to 8" under pier K-9, K-10 and K-11) line	-	Steel with X-Tru-Coat

b. 8" DFM (reduced to 6" under pier K-7 & K-8) line - Steel with X-Tru-Coat

(8) 12" Oily waste line from existing oil separation tank to oily waste Pump Station at Hotel Pier - Fiberglass

B. Existing Cathodic Protection Systems:

This section of POL lines are partially protected by an impressed current and sacrificial anode type of C.P. system.

(1) Impressed Current C.P. System - This section of the POL lines are also cathodically protected by Rectifier #8 as described in Section B-1.

(2) Sacrificial Anode Cathodic Protection System - This system consists of five test boxes and associated anodes.

a. Test Box #4 - This test box is located southwest of VC-5. Four 32 lb. prepackaged magnesium anodes were installed in 1978.

b. Test Box #5 - This test box is located west of Building 477 on Kilo Dock-9 with one 17 lb. prepackaged magnesium anode installed in 1975.

c. Test Box #6 - This test box is located each of VC-6. Five 4"x4"x36" 150 lb. zinc anodes were installed in 1978.

d. Test Box #7 - This test box is located west of VC-6 with one 17 lb. prepackaged magnesium anode installed in 1975.

e. Test Box #8 - This test box is located southwest of Building 474 with one 17 lb. prepackaged magnesium anode installed in 1975.

The anode bed open circuit potential and the current output measurements of each anode bed were measured at each test box. The results of these measurements are shown in Table No. XXII, under Section E-2.

2. Field Work and Evaluation of Data:

A. Soil Resistivity Measurements - A total of twenty-five sets of measurements were obtained at representative locations along the POL lines as shown in Table No. VII-A. The results of these measurements have been classified into various categories of corrosiveness, as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	50	Severe
Medium	2,000 - 10,000	44	Moderate
High	10,000 - 30,000	6	Slight, unless other factors are pronounced
Very High	Above - 30,000	0	Normally non-corrosive

The low resistivity indicated a severe corrosive condition on underground metallic structures. Fifty percent of the measurements obtained were in the severe category and forty-

four percent were in the medium or moderate category.

B. "As Found" Pipe-to-Soil Potentials: "As Found" pipe-to-soil potentials were obtained at each valve chamber and at each test box. The results of these measurements indicate that the POL lines of Section B-2 are not at a protective potential level. The results of these measurements are shown in Table No. VII-B.

C. Current Tests: Four current test were conducted on the POL lines of Section B-2. Pipe-to-soil potentials were obtained at the same locations as the "As Found" potentials with the test rectifier "off" and "on".

(1) Current Test No. 1 - This current test was conducted with the same anode configuration and negative connection as Current Test #1 of Section B-1. The current used for this test was 30 amperes D.C.. The results of these measurements are shown in Table No. VII-C.

(2) Current Test No. 2 - This current test was conducted with the same anode configuration and negative connection as Current Test #2 of Section B-1. The current used for this test was 28 amperes D.C.. The results of these measurements are shown in Table No. VII-D.

(3) Current Test No. 3 - This current test was conducted using the four existing 32 lb. magnesium anodes at Test Box #4 west of VC-5. The negative connection was made to the existing test lead in the test box. The current used for this test was 21 amperes D.C..

The results of these measurements are shown in Table No. VII-E.

(4) Current Test No. 4 - This test was conducted as a continuity test. Pipe-to-soil potentials were obtained at representative locations of B-2 with existing Rectifier #8 turned "off" and "on". The results of these tests are shown in Table No. VI-E, Section B-1.

Based on the data obtained from these current tests, the following results were observed:

a. POL lines of Section B-2 are electrically continuous with the POL lines of Sections B-1, B-3, B-4, B-5 and B-6 in the Pearl Harbor Complex.

b. Rectifier #8 does not provide adequate protective current for these sections.

c. The current demand for the POL lines of Section B-2 will be high.

d. No insulators were found to be installed on the POL lines of Section B-2.

e. Interference was noted on the 14" cast iron water line in VC-4 during these tests.

D. Inspection of Pipelines:

The DFM lines under K-3, K-5, K-7, K-8, K-10 and K-11 of the Kilo Pier were inspected. The following results were noted:

(1) DFM lines under K-3 and K-5.

a. Heavy rusting and corrosion has been taking place on the bolts, nuts and the 10" flange at the quay wall.

b. Coating at Pile #11 badly damaged. Heavy pitting has taken place with a pit depth of 0.05".

c. Coating damaged between Piles 15 & 16. No corrosion was noted.

d. Coating damaged at Pile 31. The roller support found to be loose and the steel plate and pad were gone.

e. Coated damaged with pitting at Pile #32.

f. Coating badly bubbled but no corrosion visible.

g. The concrete piles west of Pile #63 are totally destroyed and portions of pile cap, concrete blown from the rebar.

h. The concrete pile is completely shifted and has moved the pipe and damaged the coating.

i. The pipe support hanger at Pile 82 is fiberglass.

j. The pipe support hanger at Pump Station of K-5 and K-3 is very bad.

k. The concrete pile at Pile #11 is destroyed.

l. The concrete pile rebar was found to be electrically shorted to pipe at Pile #113.

m. Four concrete piles between Pile #111 and #118 are destroyed.

n. Pile #124 (wood pile) is broken.

o. Pile #127 (wood pile) is almost broken.

p. Pile #129 (wood pile) is gone.

q. The fuel line was found to be electrically shorted to the fresh water line at Pile #143.

(2) <u>DFM Line under K-7 and K-8</u>.

a. Pile #90 (wood pile) is broken.

b. Pile #52 (wood pile) is broken.

c. The bottom of electrical concrete manhole approximately 18' SW of Pile #30 is badly cracked.

(3) DFM Line under K-10 and K-11.

a. Heavy rusting and corrosion has taken place on the bolts, nuts and the 10" flange at the quay wall.

The bottom portions of all risers at the valve pits on Kilo Pier were checked and found to be badly corroded. The DFM lines under the Kilo Pier are X-Tru-Coated steel. Generally, the coating condition is in good condition.

E. Leak History:

The leak history was discussed with Mr. John Kimi, Mr. Edwin Katada and Mr. Albert Wong of the Base Fuel Department. Leaks on the POL lines were located and are shown on PCR Drawing No. 6478.

3. Conclusions.

Based on the field data obtained, the following results were observed:

A. Soil resistivity measurements indicate that 50% of the readings are in the severe category and 44% are in the moderate category. The environment in Section B-2 can be classified as an area of severe corrosion potential.

B. The POL lines of Section B-2 are not at a portective potential level with all potentials below -850 mv.

C. The POL lines are electrically continuous to each other from VC-3 to VC-1 and from VC-3 to Kilo Pier.

D. No insulators were found to be installed on the POL lines

of Section B-2 as called for in the construction documents.

E. The results of current tests conducted indicated that current demand for Section B-2 will be high. Approximately 24,410 sq. ft. of coated steel POL lines and 11,300 sq. ft. of X-Tru-Coated steel are to be considered for cathodic protection in Section B-2. A protective current of 50 amperes will be required to provide a protective potential level.

F. During this survey, the 14" cast iron water main in VC-4 was found to be electrically discontinuous with the POL lines.

G. No interference on the POL lines and/or on the other lines were found during this survey.

H. Rectifier #8 has not provided adequate protection current for the POL lines of Section B-1, B-3, B-4, B-5 and B-6 as we explained in Item G, under title "Conclusions" of Section B-1.

I. Inspection of the DFM lines under Kilo Pier indicate the following:

   (1) The coating of the POL lines can be considered to be in good condition. Only a small portion of coating was damaged and required repair.

   (2) The two flanges of the 10" DFM lines at the west quay wall under K-6 and K-9 in the air were found to be severely corroded and rusted.

4. <u>Recommendations</u>.

A. Current tests conducted indicated that the current demand for the underground metallic structures will require one

additional anode bed to provide protection for Section B-2. It is recommended that the additional anode bed consisting of one new oil cooled rectifier and fourteen 4½"x60" high silicon iron anodes be installed west of Building 482 and on the west side of Neosho Avenue.

B. The underground DFM lines should be isolated from the DFM lines under the Kilo Docks, preventing short circuiting between the POL lines and the re-inforcing steel.

C. The damaged coating of the DFM lines under the Kilo Docks should be repaired by recoating the lines in the damaged areas with polymastic, by the glove method.

NOTE: The location of the pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawings No. 6478.

The recommended C.P. system for Section B-2 is shown on PCR Draw:ng No. 6478-A.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM CORROSION SURVEY, SECTION B-2

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
OIL COOLED RECTIFIERS	1	ea	2250.00	2250.00	600.00	600.00	2850.00	2850.00
4½"x60" HI SI FE ANODE	14	ea	720.00	1080.00	375.00	5250.00	1095.00	15330.00
#2 HMP STRANDED COPPER CABLE	400	ft	1.50	600.00	0.15	60.00	1.65	660.00
COAL COKE BREEZE	4200	lb	0.30	1260.00	0.08	336.00	0.38	1596.00
1" PVC CLASS 200, PLASTIC PIPE	350	ft	0.75	262.50	0.15	52.50	0.90	315.00
CONCRETE PAD	1	ea	150.00	150.00	300.00	300.00	450.00	450.00
CONCRETE TEST BOX/CAST IRON LIDS	1	ea	45.00	45.00	75.00	75.00	120.00	120.00
BUTYL TAPE	2	rl	37.50	75.00	45.00	90.00	82.50	165.00
RUBBER TAPE	4	rl	7.50	30.00	7.50	30.00	15.00	60.00
PLASTIC TAPE	4	rl	7.50	30.00	7.50	30.00	15.00	60.00
COAL TAR ENAMEL (1 GALLON CAN)	1	ea	22.50	22.50	45.00	45.00	67.50	67.50
TERRA TAPE	400	ft	0.22	88.00	0.08	32.00	0.30	120.00
INSULATORS	4	ea	45.00	180.00	75.00	300.00	120.00	480.00
ALUMINO-THERMIC WELD	10	ea	3.00	30.00	37.50	375.00	40.50	405.00
TRENCH	400	ft	-	-	4.50	1800.00	4.50	1800.00
SUBTOTAL				15103.00		9375.50		24278.50
10% MISC. MATERIALS & LABOR				1510.00		937.00		2427.00

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO.: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION B-2

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
SUBTOTAL				16613.00		10312.50		26925.50
30% CONSTRUCTION PROFIT				4983.90		3093.75		8077.65
TOTAL				21596.90		13406.25		35003.15

S/N 0105-LF-010-1335
★ G.P.O.: 1979-689-016/4302

SECTION B-2

SOIL RESISTIVITIES

TABLE NO. VII-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	NW corner of Bldg. 480 E side of pipeline	16000	10000	1640
2.	NW of Bldg. 481, E side of pipeline	3000	2600	2600
3.	N end, W side of Bldg. 405 E side of pipeline	5000	3000	1260
4.	S end, W side of Bldg. 405 E side of pipeline	3400	3800	2400
5.	W of NW corner of Bldg. 482, W side of pipeline	2600	3000	1060
6.	W of Bldg. 482, W side of pipeline	2600	4000	4800
7.	N of VC-4	3500	5000	2600
8.	S of VC-4	3300	3000	2000
9.	Town area across from Bldg. 62	26000	18000	4600
10.	N side of VC-5	2500	3900	2600
11.	SW corner of Bldg. 491	3500	3000	1240
12.	SW of Bldg. 490	1650	2200	1240
13.	W of VC-7	1500	700	800
14.	W of Bldg. 477	11500	4100	880
15.	W of Bldg. 476	4000	1300	1200
16.	E of VC-6	3000	2000	1000
17.	W of Bldg. 475	1500	1300	1540
18.	W of Bldg. 474	1300	810	960

19.	W of Bldg. 462	2950	3600	1220
20.	N of Bldg. 475, W end	1000	800	800
21.	N of Bldg. 475, E end	5500	1000	500
22.	N of Flagpole, S598	2000	1100	640
23.	200' E of Rdg. #22	1000	700	600
24.	200' E of Rdg. #23	1800	1100	1000
25.	200' E of Rdg. #24	1550	760	740

SECTION B-2

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. VII-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	VC-3	
	12" JP-5 to Red Hill Tunnel	-825
	16" DFM to VC-2	-825
	18" JP-5 to VC-2	-825
	32" DFM to VC-2	-825
	6" Drain to VC-2	-870
	6" to small boat dock	-825
	8" to small boat dock	-825
	4" JP-5 to small boat dock	-500
	6" Drain to Hotel Fuel Pier	-825
	22" DFM to Hotel Fuel Pier	-825
	12" JP-5 to Hotel Fuel Pier	-825
	12" DFM to Hotel Fuel Pier	-825
	8" Defuel to Hotel Fuel Pier	-825
	4" Ballast and 12" Ballast are fiberglass.	
	8" Defuel to VC-4	-825
	18" DFM to VC-4	-825
	10" NSFO to VC-4	-825
	12" NSFO to Hotel Fuel Pier	-825
	22" DFM to Hotel Fuel Pier	-825
	12" JP-5 to Hotel Fuel Pier	-825
2.	VC-4	
	18" DFM to VC-3	-840

10" NSFO to VC-3	-840
8" Defuel to VC-3	-840
14" Water	-550
8" Defuel to VC-38	-840
8" DFM to VC-5	-840
12" DFM to VC-5	-840
8" DFM to VC-6	-840
12" DFM to VC-6	-840

3. VC-5

8" DFM to VC-7	-680
12" DFM to VC-7	-680
6" NSFO to VC-4	-680
12" DFM to VC-4	-680
12" DFM to "S" Docks	-680
8" DFM (abandoned)	-680

4. VC-7

18" DFM to VC-5	-650
12" NSFO to VC-5	-650
6" DFM to Diesel Purification Plant	-650
10" DFM to Diesel Purification Plant	-650
12" NSFO to VC-1	-650
18" DFM to VC-1	-650
8" DFM to loading rack	-650
6" DFM/NSFO to loading rack	-650

5. Truck Loading Rack

8" DFM	-645
6" DFM/NSFO	-645
Water	-440

	4" JP-5 to VC-1	-645
	4" Lube oil #1 (abandoned)	-680
	4" Lube oil #2 (abandoned)	-645
6.	VC-1	
	6" Multi.	
	HIRI side of Ins.	-840
	Navy side of Ins.	-640
	16" DFM from Pumphouse 59	-640
	18" JP-5 from Pumphouse 59	-640
	18" DFM from Pumphouse 59	-640
	12" NSFO to VC-7	-640
	18" DFM to VC-7	-640
	6" JP-5 to Loading Rack	-640
	4" Drain to VC-12	-620
	12" NSFO to Merry Pt.	-640
	18" DFm to Merry Pt.	-640
	4" Drain and 12" Ballast are fiberglass.	
7.	Hose bibb S side	-500
8.	Test Box east of VC-6	-800
9.	Test Box west of Bldg. 477	-805
10.	Test Box south of VC-6	-805
11.	Test Box southwest of Bldg. 474	-860
12.	VC-6	
	8" DFM to K-3	-805
	8" DFM to K-7 & 8	-805
	10" DFM to K-10	-805
	10" DFM to VC-4	-805
	8" DFM to VC-4	-805

SECTION B-2

CURRENT TEST NO. 1

TABLE NO. VII-C

Location:	Test Box #1, North of VC-1
Anodes used for current test:	Sixteen steel rods as temporary anodes and the existing 32 lb. magnesium anodes at the Test Box.
Negative Connection:	To existing test lead in Test Box #1.
Rectifier D.C. Output:	45 volts - 30 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Test Box N of VC-1	-790	-820	30
2.	VC-1			
	6" Multi, HIRI side of Ins.	-840	-840	0
	16" DFM from Pumphouse 59	-610	-700	90
	18" JP-5 from Pumphouse 59	-610	-700	90
	18" DFM from Pumphouse 59	-610	-700	90
	18" DFM to VC-7	-610	-700	90
	12" NSFO to VC-7	-610	-700	90
	6" JP-5 to loading rack	-610	-700	90
	4" Drain to VC-12	-610	-700	90
	12" NSFO to Merry Pt.	-610	-700	90
	18" DFM to Merry Pt.	-610	-700	90
3.	VC-7			
	18" DFM to VC-5	-660	-700	40
	12" NSFO to VC-5	-660	-700	40
	6" DFM to Diesel Purification Plant	-660	-700	40
	10" DFM to Diesel Purifi-			

	cation Plant	-660	-700	40
	12" NSFO to VC-1	-660	-700	40
	18" DFM to VC-1	-660	-700	40
	8" DFM to loading rack	-660	-700	40
	6" DFM/NSFO to loading rack	-660	-700	40
4.	Truck Loading Rack			
	8" DFM	-650	-690	40
	6" DFM/NSFO	-650	-690	40
	Water	-440	-435	-5*
	4" JP-5 to VC-1	-650	-690	40
5.	VC-5			
	8" DFM to VC-7	-735	-755	20
	12" DFM to VC-7	-735	-755	20
	6" NSFO to VC-4	-735	-755	20
	12" DFM to VC-4	-735	-755	20
	12" DFM to VC-4	-735	-755	20
	8" DFM (abandoned)	-735	-755	20
6.	Test Box W of VC-5	-735	-755	20
7.	VC-4			
	18" DFM to VC-3	-830	-845	15
	10" NSFO to VC-3	-830	-845	15
	8" Defuel to VC-3	-830	-845	15
	14" Water	-550	-545	-5*
	8" Defuel to VC-38	-830	-845	15
	8" DFM to VC-5	-830	-845	15
	12" DFM to VC-5	-830	-845	15
	8" DFM to VC-6	-830	-845	15
	12" DFM to VC-6	-830	-845	15

8.	Test Box E of VC-6	-830	-845	15
9.	VC-6			
	8" DFM to K-3	-830	-845	15
	8" DFM to K-7 & 8	-830	-845	15
	10" DFM to K-10	-830	-845	15
	10" DFM to VC-4	-830	-845	15
	8" DFM to VC-4	-830	-845	15
10.	Test Box SW of Bldg. 474	-860	-875	15
11.	Test Box W of Bldg. 477	-805	-820	15
12.	Test Box 8 E of VC-6	-805	-820	15
13.	VC-3			
	12" JP-5 to Red Hill Tunnel	-830	-850	20
	16" DFM to VC-2	-830	-850	20
	18" JP-5 to VC-2	-830	-850	20
	32" DFM to VC-2	-830	-850	20
	6" Drain to VC-2	-830	-850	20
	6" to small boat dock	-500	-505	5
	8" to small boat dock	-830	-850	20
	4" JP-5 to small boat dock	-830	-850	20
	6" Drain to Hotel Fuel Pier	-830	-850	20
	22" DFM to Hotel Fuel Pier	-830	-850	20
	12" DFM to Hotel Fuel Pier	-830	-850	20
	8" Defuel to Hotel Fuel Pier	-830	-850	20
	8" Defuel to VC-4	-830	-850	20
	18" DFM to VC-4	-830	-850	20

	10" NSFO to VC-4	-830	-850	20
	12" NSFO to VC-4	-830	-850	20
	22" DFM to Hotel Fuel Pier	-830	-850	20
	12" JP-5 to Hotel Fuel Pier	-830	-850	20
14.	VC-19	-420	-435	15

SECTION B-2

CURRENT TEST NO. 2

TABLE NO. VII-D

Location:	Test Box #3, East of VC-3
Anodes used for current test:	Seven existing 150 lb. zinc anodes.
Negative Connection:	To existing test lead in test box.
Rectifier D.C. Output:	5.5 volts - 28 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Test Box N of VC-1	-790	-820	30
2.	VC-1			
	6" Multi.			
	HIRI side of Ins.	-840	-835	-5*
	Navy side of Ins.	-620	-635	15
	16" DFM from Pumphouse 59	-620	-635	15
	18" JP-5 from Pumphouse 59	-620	-635	15
	18" DFM from Pumphouse 59	-620	-635	15
	18" DFM to VC-7	-620	-635	15
	12" NSFO to VC-7	-620	-635	15
	6" JP-5 to loading rack	-620	-635	15
	4" Drain to VC-12	-620	-635	15
	12" NSFO to Merry Pt.	-620	-635	15
	18" DFM to Merry Pt.	-620	-635	15
	4" Drain and 12" Ballast are fiberglass.			
3.	VC-7			
	18" DFM to VC-5	-645	-655	10
	12" NSFO to VC-5	-645	-655	10

6" DFM to Diesel Purification Plant	-645	-655	10
10" DFM to Diesel Purification Plant	-645	-655	10
12" NSFO to VC-1	-645	-655	10
18" DFM to VC-1	-645	-655	10
8" DFM to loading rack	-645	-655	10
6" DFM/NSFO to loading rack	-645	-655	10
4. Truck Loading Rack			
8" DFM	-645	-655	10
6" DFM/NSFO	-645	-655	10
Water	-440	-440	0
4" JP-5 to VC-1	-645	-655	10
4" Lube Oil #1 (abandoned)	-645	-655	10
4" Lube Oil #2 (abandoned)	-645	-655	10
5. VC-5			
8" DFM to VC-7	-745	-760	15
12" DFM to VC-7	-745	-760	15
6" NSFO to VC-4	-745	-760	15
12" DFM to VC-4	-745	-760	15
12" DFM to "S" Docks	-745	-760	15
8" DFM (abandoned)	-745	-760	15
6. Test Box W of VC-5	-745	-760	15
7. VC-4			
18" DFM to VC-3	-830	-855	25
10" NSFO to VC-3	-830	-855	25
8" Defuel to VC-3	-830	-855	25
14" Water	-830	-855	25

	8" Defuel to VC-38	-830	-855	25
	8" DFM to VC-5	-830	-855	25
	12" DFM to VC-5	-830	-855	25
	8" DFM to VC-6	-830	-855	25
	12" DFM to VC-6	-830	-855	25
8.	Test Box E of VC-6	-800	-810	10
9.	VC-6			
	8" DFM to K-3	-800	-810	10
	8" DFM to K-7 & 8	-800	-810	10
	10" DFM to K-10	-800	-810	10
	10" DFM to VC-4	-800	-810	10
	8" DFM to VC-4	-800	-810	10
10.	Test Box SW of Bldg. 474	-860	-870	10
11.	Test Box W of Bldg. 477	-805	-815	10
12.	Test Box SE of VC-6	-805	-815	10
13.	VC-3			
	12" JP-5 to Red Hill Tunnel	-840	-865	25
	16" DFM to VC-2	-840	-865	25
	18" JP-5 to VC-2	-840	-865	25
	32" DFM to VC-2	-840	-865	25
	6" Drain to VC-2	-840	-865	25
	6" to small boat dock	-840	-865	25
	8" to small boat dock	-840	-865	25
	4" JP-5 to small boat dock	-840	-865	25
	6" Drain to Hotel Fuel Pier	-840	-865	25
	22" DFM to Hotel Fuel Pier	-840	-865	25

12" JP-5 to Hotel Fuel Pier	-840	-865	25
12" DFM to Hotel Fuel Pier	-840	-865	25
8" Defuel to Hotel Fuel Pier	-840	-865	25
8" Defuel to VC-4	-840	-865	25
18" DFM to VC-4	-840	-865	25
10" NSFO to Hotel Fuel Pier	-840	-865	25
12" NSFO to Hotel Fuel Pier	-840	-865	25
22" DFM to Hotel Fuel Pier	-840	-865	25
12" JP-5 to Hotel Fuel Pier	-840	-865	25

SECTION B-2

CURRENT TEST NO. 3

TABLE NO. VII-E

Location: Test Box #4, West of VC-5.

Anodes used for current test: Four existing 32 lb. magnesium anodes.

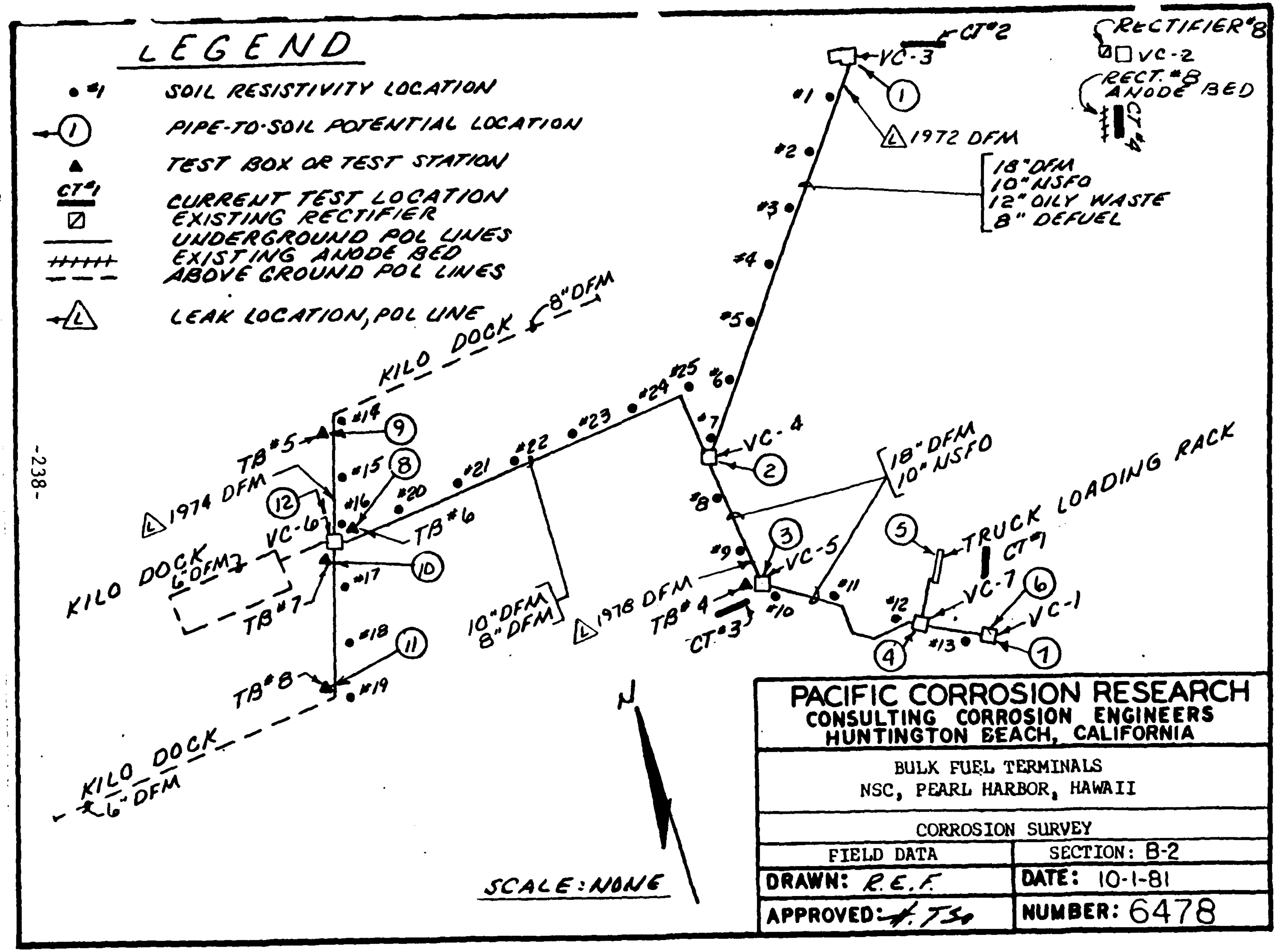
Negative Connection: To existing test lead in test box.

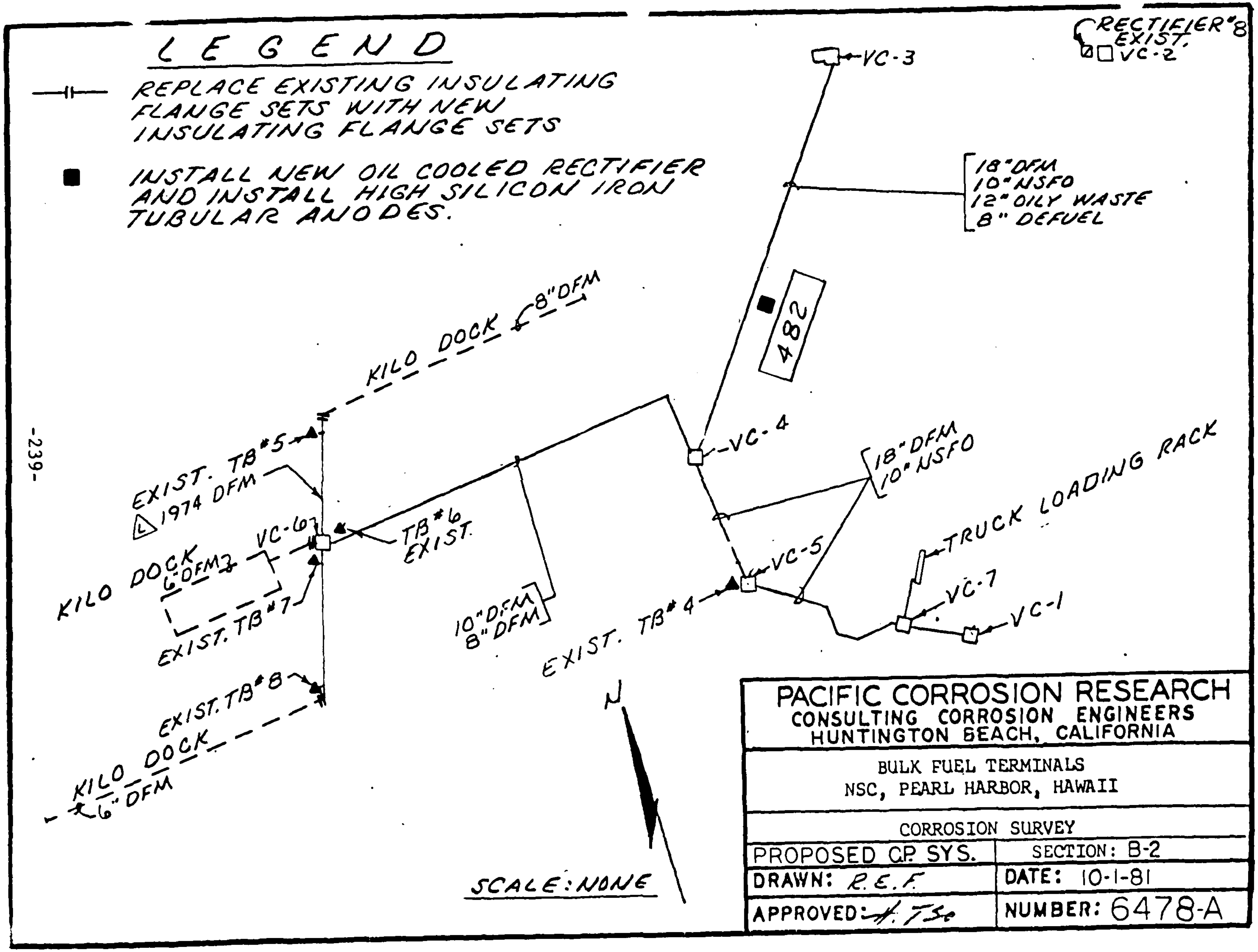
Rectifier D.C. Output: 63.5 volts - 21 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Test box N of VC-1	-915	-940	25
2.	VC-1			
	6" Multi.			
	HIRI side of Ins.	-790	-780	-10*
	Navy side of Ins.	-590	-610	20
	16" DFM from Pumphouse 59	-590	-610	20
	18" JP-5 from Pumphouse 59	-590	-610	20
	18" DFM from Pumphouse 59	-590	-610	20
	18" DFM to VC-7	-590	-610	20
	12" NSFO to VC-7	-590	-610	20
	6" JP-5 to loading rack	-590	-610	20
	4" Drain to VC-12	-590	-610	20
	12" NSFO to Merry Pt.	-590	-610	20
	18" DFM to Merry Pt.	-590	-610	20
3.	VC-7			
	18" DFM to VC-5	-655	-680	25
	12" NSFO to VC-5	-655	-680	25

	6" DFM to Diesel Purification Plant	-655	-680	25
	10" DFM to Diesel Purification Plant	-655	-680	25
	12" NSFO to VC-1	-655	-680	25
	18" DFM to VC-1	-655	-680	25
	8" DFM to Loading Rack	-655	-680	25
	6" DFM/NSFO to Loading Rack	-655	-680	25
4.	Truck Loading Rack			
	8" DFM	-655	-680	25
	6" DFM/NSFO	-655	-680	25
	Water	-440	-435	-5*
	4" JP-5 to VC-1	-655	-680	25
5.	VC-5			
	8" DFM to VC-7	-700	-980	280
	12" DFM to VC-7	-700	-980	280
	6" NSFO to VC-4	-700	-980	280
	12" DFM to VC-4	-700	-980	280
	8" DFM (abandoned)	-700	-980	280
6.	Test Box W of VC-5	-700	-980	280
7.	VC-4			
	18" DFM to VC-3	-830	-875	45
	10" NSFO to VC-3	-830	-875	45
	8" Defuel to VC-3	-830	-875	45
	14" Water	-545	-545	0
	8" Defuel to VC-38	-830	-875	45
	8" DFM to VC-5	-830	-875	45
	12" DFM to VC-5	-830	-875	45

	8" DFM to VC-6	-830	-875	45
	12" DFM to VC-6	-830	-875	45
8.	Test Box E of VC-6	-810	-835	25
9.	VC-6			
	8" DFM to K-3	-810	-835	25
	8" DFM to K-7 & 8	-810	-835	25
	10" DFM to K-10	-810	-835	25
	10" DFM to VC-4	-810	-835	25
	8" DFM to VC-4	-810	-835	25
10.	Test Box SW of Bldg. 474	-860	-870	10
11.	Test Box W of Bldg. 477	-870	-880	10
12.	Test Box SE of VC-6	-810	-835	25


LEGEND
#1 SOIL RESISTIVITY LOCATION
1 PIPE-TO-SOIL POTENTIAL LOCATION
TEST BOX OR TEST STATION
CT#1 CURRENT TEST LOCATION
EXISTING RECTIFIER
UNDERGROUND POL LINES
EXISTING ANODE BED
ABOVE GROUND POL LINES
L LEAK LOCATION, POL LINE
VC-3
CT#2
RECTIFIER #8
VC-2
RECT. #8 ANODE BED
CT#4
1972 DFM
18" DFM
10" NSFO
12" OILY WASTE
8" DEFUEL
#1
#2
#3
#4
#5
#6
#7
VC-4
#8
#9
#10
#11
#12
#13
VC-5
18" DFM
10" NSFO
TRUCK LOADING RACK
CT#1
VC-7
VC-1
1978 DFM
TB#4
CT#3
KILO DOCK 8" DFM
#14
#15
#16
#17
#18
#19
#20
#21
#22
#23
#24
#25
TB#5
1974 DFM
VC-6
TB#6
KILO DOCK 6" DFM
TB#7
10" DFM
8" DFM
TB#8
KILO DOCK 6" DFM
N
SCALE: NONE
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA
BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII
CORROSION SURVEY
FIELD DATA
SECTION: B-2
DRAWN: R.E.F.
DATE: 10-1-81
APPROVED: H.TS.
NUMBER: 6478



LEGEND
REPLACE EXISTING INSULATING FLANGE SETS WITH NEW INSULATING FLANGE SETS
INSTALL NEW OIL COOLED RECTIFIER AND INSTALL HIGH SILICON IRON TUBULAR ANODES.
RECTIFIER #8 EXIST.
VC-2
VC-3
18" DFM
10" NSFO
12" OILY WASTE
8" DEFUEL
482
VC-4
18" DFM
10" NSFO
TRUCK LOADING RACK
VC-5
VC-7
VC-1
EXIST. TB# 4
10" DFM
8" DFM
KILO DOCK
8" DFM
EXIST. TB#5
EXIST. 1974 DFM
VC-6
TB#6 EXIST.
KILO DOCK 6" DFM
EXIST. TB#7
EXIST. TB#8
KILO DOCK 6" DFM
N
SCALE: NONE
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA
BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII
CORROSION SURVEY
PROPOSED CP SYS.
SECTION: B-2
DRAWN: R.E.F.
DATE: 10-1-81
APPROVED:
NUMBER: 6478-A

SECTION B-3

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE LINES FROM VC-4 TO SIERRA PIERS

SECTION B-3

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE LINES FROM VC-4 TO SIERRA PIERS

SECTION B-3

SUMMARY

1. Conclusions:

Based on the field data obtained, the following results were observed:

A. The soil environment in Section B-3 can be classified as an area of severe corrosion potential.

B. The POL lines of Section B-3 are not at a protective potential level.

C. The POL lines of Section B-3 are electrically continuous to each other from VC-4 to Sierra Piers.

D. No insulators were found to be installed on the POL lines as called for in the most recent construction documents.

E. Approximately 2,550 sq. ft. of X-Tru-Coated steel POL lines are to be considered for cathodic protection. A protective current of 5 amperes D.C. will be required to accomplish the achievement.

F. The POL lines were found to be electrically continuous with the air line at Building 644 but discontinuous with the water line at Building 644.

2. Recommendations:

A. It is recommended that the underground POL lines be isolated from the above ground POL lines in VC-19 and VC-38.

B. Current tests conducted indicated three new sacrificial anode beds will be required to provide protection for the underground POL lines of Section B-3. Each anode bed will consist of one test box and five 50 lb. prepackaged magnesium anodes and should be installed at the following locations:

(1) Anode Bed #1 - 80' South of VC-5
(2) Anode Bed #2 - 80' North of VC-19
(3) Anode Bed #3 - 80' Northeast of VC-38

SECTION B-3

POL LINES INSIDE THE PEARL HARBOR COMPLEX INCLUDING THE LINES FROM VC-4 TO SIERRA PIERS

1. Description.

   A. Lines to be Protected:

      (1) From VC-4 to VC-19

         a. 8" DEF line - Coated Steel

      (2) From VC-5 to VC-19

         a. 12" DFM line - Steel with X-Tru-Coat

      (3) From VC-19 to VC-38

         a. 6" DEF line - Steel with X-Tru-Coat

         b. 8" DFM line - Steel with X-Tru-Coat

      (4) POL line under Sierra Piers

         a. The X-Tru-Coat steel DEF and DFM line under the Sierra Piers are in air and are supported by hangers.

   B. Existing Cathodic Protection Systems:

   The POL lines of Section B-3 are also to be protected by existing Rectifier #8. The D.C. output of Rectifier #8 and the locations of anode beds are described in Section B-1.

2. Field Work and Evaluation of Data.

   A. Soil Resistivity Measurements - A total of fifteen sets of measurements were obtained at representative locations and are shown in Table No. VIII-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	63	Severe
Medium	2,000 - 10,000	37	Moderate
High	10,000 - 30,000	0	Slight, unless other factors are pronounced
Very High	Above - 30,000	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on underground metallic structures. Sixty-three percent of the measurements obtained were in the severe category and thirty-seven percent were in the medium category.

B. "As Found" Pipe-to-Soil Potentials - "As Found" pipe-to-soil potentials were obtained at each valve chamber. The results of these measurements indicated that the underground POL lines of Section B-3 are not at a protective potential level. The results of these measurements are shown in Table No. VIII-B.

C. Current Tests - Three current tests were conducted on this section of POL lines. Pipe-to-soil potentials were obtained at the same locations as the "As Found" potentials with the test rectifier "off" and "on"..

(1) Current Test No. 1 - This current test was conducted in the area adjacent to VC-5. The existing four 32

lb. prepackaged magnesium anodes at Test Box #4 were used as a temporary anode bed. The negative from the test rectifier was connected to the pipe test lead at Test Box #4. The current used for this test was 10 amperes D.C.. The results of this test are shown in Table No. VIII-C.

(2) Current Test No. 2 - This current test was conducted with the same anode bed configuration and the same negative as Current Test No. 1. The current was increased to 21 amperes D.C.. The results of this test are shown in Table No. VIII-D.

(3) Current Test No. 3 - This current test was conducted as a continuity test. Pipe-to-soil potentials were obtained at each Valve Chamber of Section B-3 with the existing Rectifier #8 turned "off" and "on". The results of this test are shown in Table No. VI-E, Section B-1.

Based on the data obtained from these current tests, the following results were observed:

a. The POL lines of Section B-3 are electrically continuous with the POL lines of Section B-1, B-2, B-4 and B-5.

b. Rectifier #8 had not provided adequate protection for POL lines and tanks of these sections.

c. The current requirement for POL lines of Section B-3 will be moderate.

d. The POL lines were found to be electrically con-

tinuous with the air line at Building 644 but, electrically discontinuous with the water line at Building 644.

D. Inspection of Pipeline:

The POL lines under Sierra Pier were inspected on August 31, 1981. The POL lines are X-Tru-Coated steel pipe and are supported by hangers. The coating of the POL lines was found to be in good condition.

E. Leak History:

The leak history was discussed with Mr. John Kimi of the Base Fuel Department. We were advised by Mr. Kimi that only one leak in the 8" defuel line near VC-19 was found in 1967 and repaired by welding a plate to the leak area. The location of leak is shown on PCR Drawing No. 6479.

3. Conclusions.

Based on the field data obtained, the following results were observed:

A. Soil resistivity measurements obtained indicated that 63% of readings are in the severe category and 37% in the moderate category. The environment in Section B-3 can be classified as an area of severe corrosion potential.

B. The POL lines of Section B-3 are not at a protective potential level.

C. The POL lines of Section B-3 are electrically continuous to each other from VC-4 to Sierra Piers.

D. No insulators were found to be installed on the POL lines as called for in the most recent construction documents.

E. The results of current tests conducted indicated that the current demand for Section B-3 will be moderate. Approximately 2,550 sq. ft. of X-Tru-Coated steel POL lines are to be considered for cathodic protection. A protective current of 5 amperes D.C. will be required to accomplish the achievement.

F. The POL lines were found to be electrically continuous with the air line at Building 644 but discontinuous with the water line at Building 644.

G. Rectifier #8 has not provided adequate protective current for the POL lines of this section.

H. The coating of the POL lines under Sierra Piers can be considered in good condition.

4. <u>Recommendations</u>.

A. It is recommended that the underground POL lines be isolated from the above ground POL lines in VC-19 and VC-38.

B. Current tests conducted indicated that the three new sacrificial anode beds will be required to provide protection for the underground POL lines of Section B-3. Each anode bed will consist of one test box and five 50 lb. prepackaged magnesium anodes and should be installed at the following locations:

Anode Bed #1	-	80' South of VC-5
Anode Bed #2	-	80' North of VC-19
Anode Bed #3	-	80' Northwest of VC-38

NOTE: The locations of the pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No. 6479.

The recommended C.P. system for Section B-3 is shown on PCR Drawing No. 6479-A.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982 | SHEET 1 OF 1

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION B-3

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify)

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
50 LB. PREPACKAGED MAGNESIUM ANODES	15	ea	225.00	3375.00	150.00	2250.00	375.00	5625.00
#8 HMP STRANDED COPPER CABLE	100	ft	0.75	75.00	0.15	15.00	0.90	90.00
1" PVC CLASS 200, PLASTIC PIPE	300	ft	0.75	225.00	0.37	111.00	112.00	336.00
TERRA TAPE	150	ft	0.22	33.00	0.08	12.00	0.30	45.00
SPLIT BOLT	8	ea	1.05	8.40	4.50	36.00	5.55	44.40
CONCRETE TEST BOX/CAST IRON LIDS	5	ea	45.00	225.00	75.00	375.00	120.00	600.00
HOSE CONNECTION ADAPTER	2	ea	7.50	15.00	7.50	15.00	15.00	30.00
0.01 OHM SHUNT	2	ea	7.50	15.00	7.50	15.00	15.00	30.00
BRASS TAGS	10	ea	1.50	15.00	1.50	15.00	3.00	30.00
TRENCH	120	ft	-	-	4.50	540.00	4.50	540.00
INSULATORS	8	ea	45.00	360.00	75.00	600.00	120.00	960.00
SUBTOTAL				4346.40		3984.00		8330.40
10% MISC. MATERIALS & LABOR				434.64		398.40		833.04
SUBTOTAL				4781.04		4382.40		9163.44
30% CONSTRUCTION PROFIT				1434.31		1314.72		2749.03
TOTAL				6215.35		5697.12		11912.47

S/N 0105-LF-010-1335
★ G.P.O.: 1979-689-016/4302

SECTION B-3

SOIL RESISTIVITIES

TABLE NO. VIII-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	VC-38	3000	2100	1360
2.	VC-19	1800	6700	1400
3.	W corner of Bldg. 645	2550	2800	940
4.	N corner of Bldg. 645	3000	1900	1060
5.	N side of VC-5	2500	3900	2600
6.	S of Bldg. 641	30000	10000	2000
7.	S of Bldg. 324	2050	1100	600
8.	S of Bldg. 416	1000	510	300
9.	SW of Bldg. 445	1000	700	400
10.	SE of Bldg. 472	650	570	400
11.	S of Bldg. 1204	1200	610	520
12.	SW of Bldg. 414	1400	700	520
13.	N of Station S21	2300	2500	3800
14.	SE of Bldg. 484	1900	1600	800
15.	W end of N side of Magazine Lock	6500	3700	1100

SECTION B-3

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. VIII-B

Rdg. No	Location	Pipe-to-Soil Potentials (mv)
1.	VC-5	
	8" DFM to VC-7	-680
	12" DFM to VC-7	-680
	6" NSFO to VC-41	-680
	12" DFM to VC-4	-680
	12" DFM to "S" Docks	-680
	8" DFM (abandoned)	-680
2.	Test Box West of VC-5	-730
3.	VC-19	
	8" DFM (abandoned)	-425
	12" DFM to VC-5	-425
4.	VC-38	
	6" to Purification Platn	-590
	4" (abandoned)	-590
	4" Defuel to "S" Docks	-590
	6" Defuel (abandoned)	-590
	6" Defuel to VC-4	-590
	4" DFM (abandoned)	-590
	4" DFM to Purification Plant	-590
5.	Pumphouse #60 - All Lines	-390
6.	Water, Near VC-38	-550
7.	VC-4	

18" DFM to VC-3	-830
10" NSFO to VC-3	-830
8" Defuel to VC-3	-830
14" Water	-545

SECTION B-3

CURRENT TEST NO. 1

TABLE NO. VIII-C

Location:	Test Box West of VC-5
Anodes used for current test:	Four existing 32 lb. prepackaged magnesium anodes.
Negative Connection:	To existing test lead in Test Box.
Rectifier D.C. Output:	39.0 volts - 10 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC-5			
	8" DFM to VC-7	-700	-820	120
	12" DFM to VC-7	-700	-820	120
	6" NSFO to VC-4	-700	-820	120
	12" DFM to VC-4	-700	-820	120
	12" DFM to "S" Docks	-700	-820	120
	8" DFM (abandoned)	-700	-820	120
2.	Negative connection in Test Box W of VC-5	-700	-820	120
3.	Water to Bldg. 644	-520	-515	- 5*
4.	Air to air tanks, east of Bldg. 644	-565	-595	30
5.	VC-19			
	8" DFM (abandoned)	-420	-455	35
	12" DFM to VC-5	-420	-455	35
6.	VC-38			
	6" to Purification Plant	-600	-605	5
	4" (Abandoned)	-600	-605	5

	4" Defuel to "S" Dock	-600	-605	5
	6" Defuel (abandoned)	-600	-605	5
	6" Defuel to VC-4	-600	-605	5
	4" DFM (abandoned)	-600	-605	5
	4" DFM to Purification Plant	-600	-605	5
7.	Water near VC-38	-550	-555	5
8.	Bldg. 60 (all lines)	-390	-395	5
9.	VC-4			
	18" DFM to VC-3	-830	-855	25
	10" NSFO to VC-3	-830	-855	25
	8" Defuel to VC-3	-830	-855	25
	14" Water	-545	-545	0
10.	VC-6			
	8" DFM to K-3	-805	-820	15
	8" DFM to K-7 & 8	-805	-820	15
	10" DFM to K-10	-805	-820	15
	10" DFM to VC-4	-805	-820	15
	8" DFM to VC-4	-805	-820	15
11.	VC-3			
	18" DFM to VC-4	-830	-835	5
	10" NSFO to VC-4	-830	-835	5
	8" Defuel to VC-4	-830	-835	5
12.	VC-7			
	18" DFM to VC-5	-655	-670	15
	12" NSFO to VC-5	-655	-670	15
13.	VC-1			
	6" Multi., HIRI side of Ins.	-790	-785	-5*

14.	Test Box North of VC-1	-915	-920	5

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION B-3

CURRENT TEST NO. 2

TABLE NO. VIII-D

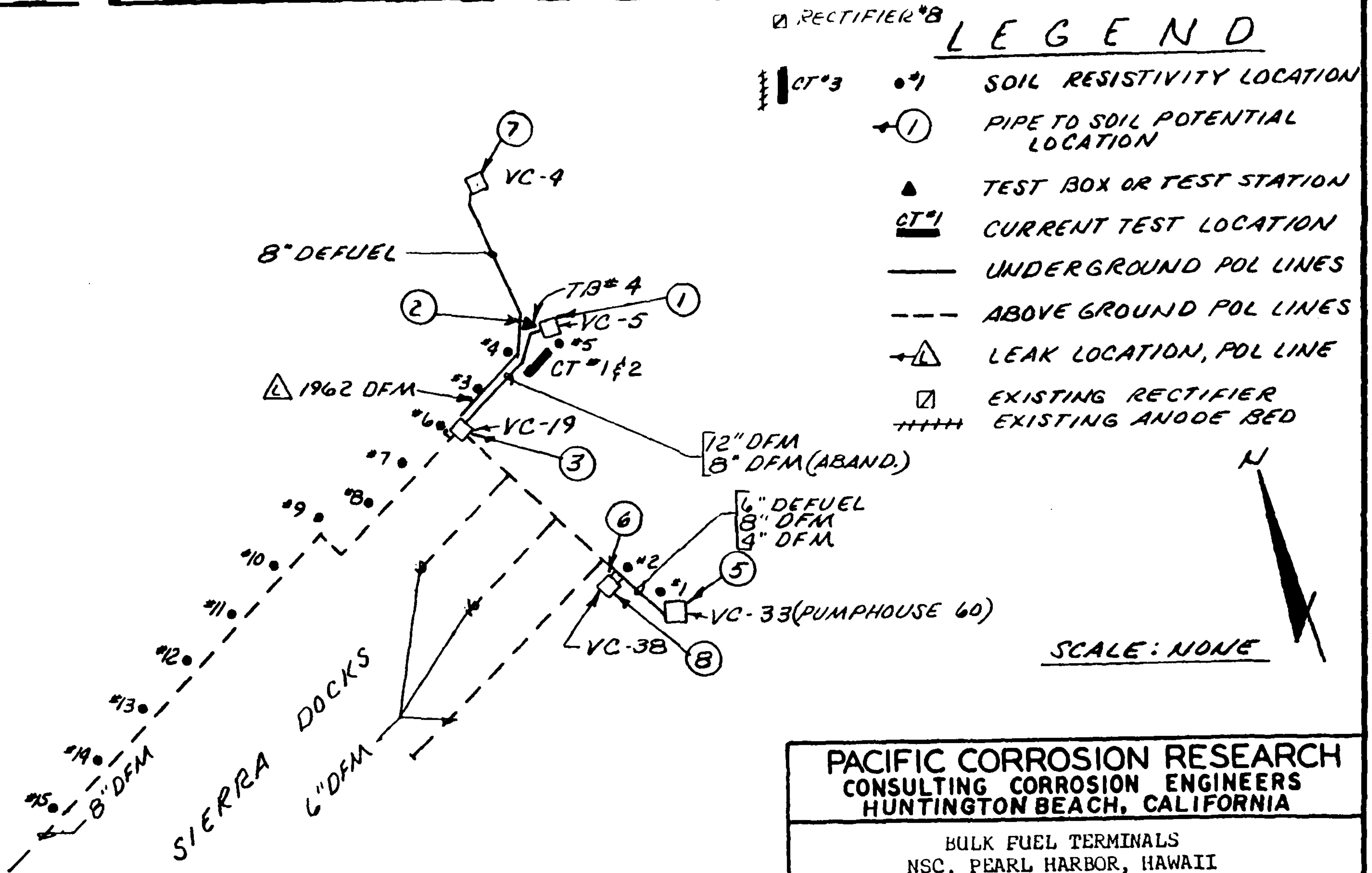
Location:	Test Box west of VC-5.
Anodes for current test:	Four existing 32 lb. prepackaged magnesium anodes.
Negative connection:	To existing test lead in test box.
Rectifier D.C. Output:	63.5 volts - 21 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC-5			
	8" DFM to VC-7	-700	-980	280
	12" DFM to VC-7	-700	-980	280
	6" NSFO to VC-4	-700	-980	280
	12" DFM to VC-4	-700	-980	280
	12" DFM to "S" Docks	-700	-980	280
	8" DFM (abandoned)	-700	-980	280
2.	Negative Connection in Test Box, West of VC-5	-700	-980	280
3.	Water to Bldg. 644	-520	-515	-5*
4.	Air to Air Tanks, East of Bldg. 644	-565	-620	55
5.	VC-19			
	8" DFM (abandoned)	-420	-475	55
	12" DFM to VC-5	-420	-475	55
6.	VC-38			
	6" to Purification Plant	-600	-605	5
	4" (abandoned)	-600	-605	5
	4" Defuel to "S"Docks	-600	-605	5

	6" Defuel (abandoned)	-600	-605	5
	6" Defuel to VC-4	-600	-605	5
	4" DFM (abandoned)	-600	-605	5
	4" DFM to Purification Plant	-600	-605	5
7.	Water near VC-38	-550	-555	5
8.	Bldg. 60 (all lines)	-390	-400	10
9.	VC-4			
	18" DFM to VC-3	-830	-875	45
	10" NSFO to VC-3	-830	-875	45
	8" Defuel to VC-3	-830	-875	45
	14" Water	-545	-545	0
10.	VC-6			
	8" DFM to K-3	-805	-840	35
	8" DFM to K-7 & 8	-805	-840	35
	10" DFM to K-10	-805	-840	35
	10" DFM to VC-4	-805	-840	35
	8" DFM to VC-4	-805	-840	35
11.	VC-3			
	18" DFM to VC-4	-830	-835	5
	10" NSFO to VC-4	-830	-835	5
	8" Defuel to VC-4	-830	-835	5
12.	VC-7			
	18" DFM to VC-5	-655	-680	25
	12" NSFO to VC-5	-655	-680	25
13.	VC-1			
	6" Multi., HIRI side of Ins.	-790	-780	-10*

14.	Test Box North of VC-1	-915	-940	25

*A minus change indicates .hat the pipe-to-soil potential became less negative as a result of application of test current.



PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA

BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII

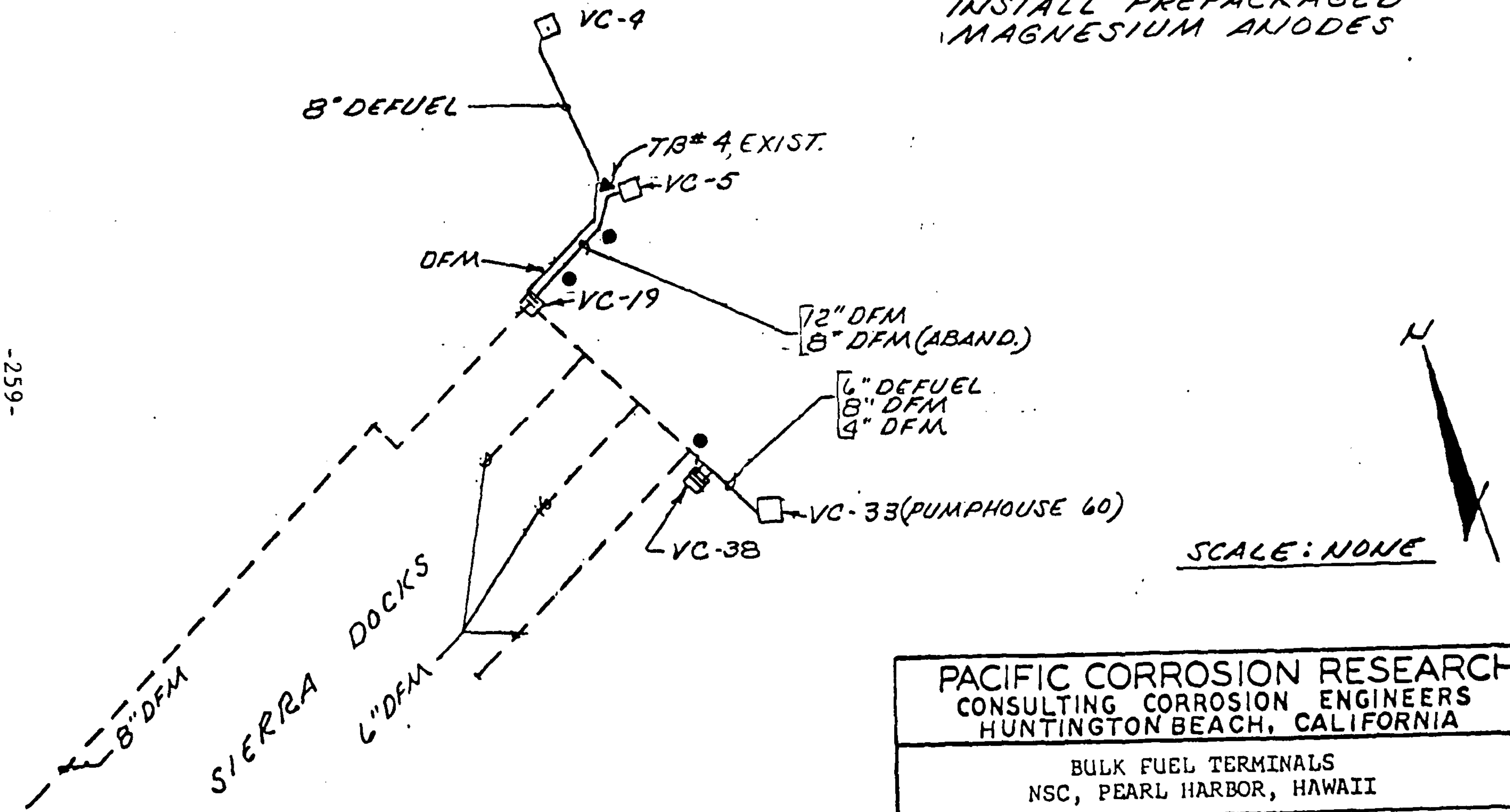
CORROSION SURVEY

FIELD DATA	SECTION: B-3
DRAWN: R.E.F.	DATE: 9-30-81
APPROVED: H. T30	NUMBER: 6479

LEGEND

—||— INSTALL NEW INSULATING FLANGE SETS

● INSTALL NEW TEST BOX AND INSTALL PREPACKAGED MAGNESIUM ANODES



SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED C.P. SYS.	SECTION: B-3
DRAWN: R.E.F.	DATE: 9-30-81
APPROVED: H. Tso	NUMBER: 6479-A

SECTION B-4

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE LINES FROM VC-1 TO SIERRA PIER, MIKE DOCKS AND UPPER TANK FARM

SECTION B-4

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE LINES FROM VC-1 TO SIERRA PIER, MIKE DOCKS AND UPPER TANK FARM

SECTION B-4

SUMMARY

1. Conclusions:

Based on the field data obtained, the following results were observed:

A. The soil environment in Section B-4 can be classified as an area of severe corrosion potential.

B. The POL lines of Section B-4 are not at a protective potential level.

C. The POL lines of Section B-4 are electrically continuous to each other from VC-1 to VC-31.

D. No insulators were found to be installed.

E. Approximately 7,900 sq. ft. of underground POL lines are to be considered for cathodic protection in Section B-4. A protective current of 12 amperes will be required to provide a protective potential to the lines.

F. The gas and water lines south of Building 678 were found to be electrically continuous with the POL lines.

G. No interference to the POL lines and/or to the other lines were found during this survey.

H. Existing Rectifier #9 was originally installed southwest of Tank #36 (5748) at the Middle Tank Farm. The anode header cable was checked and found to be broken under the parking area near the rectifier location. A new rectifier (#9) with nine (9) 3"x60" graphite anodes were installed south of Building 229 by Mr. John Kimi and his staff, in 1979. The capacity of Rectifier #9 is 40 volts and 80 amperes D.C. This rectifier was checked and was operating above its maximum D.C. rating with a tap setting of 4 (coarse) - 5 (fine) with a D.C. output

of 50 volts and 9 amperes. The D.C. output of this rectifi can not be adjusted to a higher current output due to the following reasons:

(1) Lack of additional D.C. current.

(2) Inadequate anodes.

(3) Anodes installed in a high resistivity environment ie: installed in sand and/or in dry high resistance soil.

2. Recommendations:

A. The current tests conducted indicated the protection for this portion of the underground POL lines will require one additional sacrificial anode bed. It is recommended that this anode bed consist of one test box and five (5) 4"x4"x36" 150 lb. zinc anodes installed south of Building 678 in Lillican Field. A majority of the underground POL lines of Section B-4 will be protected by additional rectifiers which will be described in Sections B-5, B-6 and C-2.

B. The above ground POL lines should be isolated from the underground POL lines at VC-31 and VC-32.

SECTION B-4

POL LINES INSIDE THE PEARL HARBOR COMPLEX INCLUDING THE LINES FROM VC-1 TO SIERRA PIER, MIKE DOCKS AND UPPER TANK FARM

1. Description.

A. Lines to be Protected:

(1) From VC-1 to VC-9

a. 16" DFM line - Coated Steel

(2) From VC-7 to Diesel Purification Plant

a. 10" DFM line - Coated Steel

b. 6" DFM line - Coated Steel

(3) VC-9 to VC-8

a. 16" DFM line

b. 10" NSFO line

(4) VC-8 to Building 60

a. 8" DFM line - Coated Steel

(5) VC-8 to VC-13

a. 12" DFM line - Coated Steel

b. 16" DFM line - Coated Steel

(6) VC-13 to VC-32

a. 8" DFM line - Coated Steel

b. 12" DFM line - Steel with X-Tru-Coat

(7) VC-32 to VC-31

a. 12" DFM line - Steel with X-Tru-Coat

(8) VC-31 to VC-20

a. 12" DFM line - The 12" X-Tru-Coat steel DFM line under the Mike Docks is in

air and is supported by hangers.

B. <u>Existing Cathodic Protection System</u>:

This section of lines are partially protected by an impressed current and a sacrificial anode C.P. system.

1) <u>Impressed Current C.P. System</u>: This system consists of two rectifiers and associated beds.

a. Rectifier #8 - as described in Section B-1.

b. Rectifier #9 -

(i) Rectifier Location: Rectifier #9 is located on the west side of Building 553.

(ii) Rectifier Unit:
Mfg. - Goodall
Serial No. - 79C1380
D.C. Capacity - 40 V, 80 A
Operating at - Tap setting 4-5
D.C. Output - 50 V, 9 A
Date Recorded - Aug. 24, 1981

(iii) Anode Bed Location: Nine 3"x60" graphite anodes installed south of Building 229 in 1979.

(2) <u>Sacrificial Anode Cathodic Protection System</u>: This system consists of two test boxes, two 4"x4"x36" - 150 lb. zinc anodes and one 17 lb. prepackaged magnesium anode.

a. Test Box #9 - This test box is located 25' north of VC-32. One 17 lb. prepackaged magnesium anode

was installed in 1975.

b. Test Box #10 - This test box is located 88' east of VC-32. Two 4"x4"x36" - 150 lb. zinc anodes were installed in 1978.

The anode bed open circuit potential and current output measurements of each anode bed were obtained at each test box. The results of these measurements are shown in Table No. XXII under Section E-2.

2. Field Data and Evaluation of Data.

A. Soil Resistivity Measurements: A total of twelve sets of measurements were obtained at representative locations as shown in Table No. IX-A. The results of these measurements have been classified into various categories of corrosiveness in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	53	Severe
Medium	2,000 - 10,000	33	Moderate
High	10,000 - 30,000	14	Slight unless other factors are pronounced
Very Hight	Above - 30,000	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on underground metallic structures. Fifty-three percent of

the measurements obtained were in the severe category and thirty-three percent were in the medium or moderate category.

B. "As Found" Pipe-to-Soil Potentials: "As Found" pipe-to-soil potentials were obtained at each valve chamber and at each test box. The results of these measurements indicate that the POL lines of Section B-4 are not at a protective potential level. The results of these measurements are shown in Table No. IX-B.

C. Current Tests: Five current tests were conducted on the POL lines of Section B-4. Pipe-to-soil potentials were obtained at the same locations as the "As Found" potentials with the test rectifier "off" and "on".

(1) Current Test No. 1 - This test was conducted in the area adjacent to Test Box #10. Eight steel rods were installed north of Test Box #11 as a temporary anode bed. A test rectifier was used for a D.C. power sources. The current used for this test was 11.5 amperes D.C. with a negative from the test rectifier connected to the test lead at Test Box #11. The results of this test are shown in Table No. IX-C.

(2) Current Test No. 2 - This test was conducted with the same anode configuration and negative connection as Current Test No. 1. The current was increased to 23 amperes D.C.. The results of this test are shown in Table No. IX-D.

(3) Current Test No. 3 - This test was conducted in the lawn area near VC-21. Fourteen steel rods, two posts

and a short section of fence were used as a temporary anode bed. A test rectifier was used for a D.C. power source. The negative from the test rectifier was connected to the POL line at VC-21. The results of this test are shown in Table No. IX-3.

(4) Current Test No. 4 - This current test was conducted as a continuity test. Pipe-to-soil potentials were obtained at each valve chamber of Section B-4 with the existing Rectifier #8 turned "off" and "on". The results of this test are shown in Table No. VI-E, Section B-1.

(5) Current Test No. 5 - This current test was also conducted as a continuity test. Pipe-to-soil potentials were obtained at representative locations with the existing Rectifier #9 turned "off" and "on". The results of this test are shown in Table No. IX-F.

Based on the data obtained from these current tests, the following results were observed:

a. The POL lines of Section B-4 are electrically continuous with the POL lines of Section B-1 through B-9.

b. Rectifiers #8 and #9 do not provide adequate protective current for these actions.

c. The gas and water lines were found to be electrically continuous with the POL lines.

d. Most of the POL lines of Section B-4 are either above ground or under piers in air. The current

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A-E SERVICES TO PERFORM A CATHODIC PROTECTION SURVEY OF THE BUL--ETC(U)
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demand for the underground POL lines will not be high.

e. No insulators were found installed on the POL lines of Section B-4.

D. Inspection of Pipelines: The POL lines under the Mike Docks were inspected on August 29, 1981. The POL lines are steel pipe with X-Tru-Coat and are supported by hangers. The coating of the POL lines was found to be in good condition.

E. Leak History: The leak history was discussed with Mr. John Kimi, of the Base Fuel Department. We were advised that there were numerous leaks that had taken place on the POL lines in the area east of Building 60 since 1975. Two leaks on the POL line under the Mike Docks were found and repaired in 1969. The leak locations are shown on PCR Drawing No. 6480.

3. Conclusions.

Based on the field data obtained, the following results were observed:

A. Soil resistivity measurements indicate that 53% of the readings are in the severe category and 33% are in the moderate category. The environment in Section B-4 can be classified as an area of severe corrosion potential.

B. The POL lines of Section B-4 are not at a protective potential level.

C. The POL lines of Section B-4 are electrically continuous to each other from VC-1 to VC-31.

D. No insulators were found installed.

E. The results of current tests conducted indicated that the current demand for this section will be moderate. Approximately 7,900 sq. ft. of underground POL lines are to be considered for cathodic protection in Section B-4. A protective current of 12 amperes will be required to provide a protective potential to the lines.

F. The gas and water lines south of Building 678 were found to be electrically continuous with the POL lines.

G. No interference to the POL lines and /or to the other lines were found during this survey.

H. Rectifier #8 has not provided adequate protective current for the POL lines of Section B-1 through B-6 as we explained in Item G, under the title "Conclusions" of Section B-1. Existing Rectifier #9 was originally installed southwest of Tank 36 (5748) at the Middle Tank Farm. The anode header cable was checked and found to be broken under the parking area near the rectifier location. A new rectifier (#9) with nine - 3"x60" graphite anodes were installed south of Building 229 by Mr. John Kimi and his staff in 1979. The capacity of Rectifier #9 is 40 volts and 80 amperes D.C.. This rectifier was checked and was operating above its maximum D.C. rating with a tap setting of 4 (coarse) - 5 (fine) with a D.C. output of 50 volts and 9 amperes. The D.C. output of this rectifier can not be adjusted to a higher current output due to the following reasons:

(1) Lack of D.C. additional voltage capacity.

(2) Inadequate anodes.

(3) Anodes installed in a high resistivity environment ie: installed in sand and/or in dry high resistance soil.

Therefore, Rectifier #9 does not provide adequate protective current for the POL lines of Sections B-4, B-6, B-7 and C-3.

I. Visual inspection of the POL lines under Mike Docks indicates that they are coated with X-Tru-Coat. The POL lines above ground from VC-9 to VC-13 are covered by a light green protective paint coating. The paint coating was found to be in good condition.

4. Recommendations.

A. The current tests conducted indicated that the protection for this portion of the underground POL lines will require one additonal sacrificial anode bed. It is recommended that this anode bed consist of one test box and five 4"x4"x36" 150 lb. zinc anodes installed south of Building 678 in Millican Field. A majority of the underground POL lines of Section B-4 will be protected by additional rectifiers which will be described in Section B-5, B-6 and C-2.

B. The above ground POL lines should be isolated from the underground POL lines at VC-31 and VC-32.

NOTE: The locations of the pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No. 6480.

The recommended C.P. system for Section B-4 is shown on PCR Drawing No. 6480-A.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982 | SHEET 1 OF 1

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION B-4

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ______

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
4"x4"x36" 150 LB. ZINC ANODES	5	ea	450.00	2250.00	150.00	750.00	600.00	3000.00
CONCRETE TEST BOX/CAST IRON LID	1	ea	45.00	45.00	75.00	75.00	120.00	120.00
#8 HMP STRANDED COPPER CABLE	50	ft	0.75	37.50	0.15	7.50	0.90	45.00
1" PVC CLASS 200, PLASTIC PIPE	50	ft	0.75	37.50	0.37	18.50	1.12	56.00
TERRA TAPE	60	ft	0.22	13.20	0.08	4.80	0.30	18.00
SPLIT BOLTS	2	ea	1.05	2.10	4.50	9.00	5.55	11.10
HOSE CONNECTION ADAPTER	1	ea	7.50	7.50	7.50	7.50	15.00	15.00
0.01 OHM SHUNT	1	ea	7.50	7.50	7.50	7.50	15.00	15.00
BRASS TAGS	3	ea	1.50	4.50	1.50	4.50	3.00	9.00
INSULATORS	2	ea	45.00	90.00	75.00	150.00	120.00	240.00
TRENCH	50	ft	-	-	4.50	225.00	4.50	225.00
SUBTOTAL				2494.80		1259.30		3754.10
10% MISC. MATERIALS & LABOR				249.48		125.93		375.41
SUBTOTAL				2744.28		1385.23		4129.51
30% CONSTRUCTION PROFIT				823.28		415.59		1238.85
TOTAL				3567.56		1800.80		5368.36

S/N 0105-LF-010-1335
★ G.P.O.: 1979-689-016/4302

SECTION B-4

SOIL RESISTIVITY MEASUREMENTS

TABLE NO. IX-A

Rdg. No.	Location	Soil Resistivity (ohm-cms) Depth 2.5'	5'	10'
1.	West of VC-7	1500	700	800
2.	East of VC-1	10000	360	200
3.	East of Bldg. 795	3100	2000	800
4.	West of Bldg. 235	2800	4000	1700
5.	North of VC-9	2800	1100	1020
6.	North of Bldg. 60	14000	5100	1160
7.	North side of Bole St., E. of North Rd.	5000	2000	680
8.	West of VC-14	7500	5900	3000
9.	West of East fence in Millicon Field	23000	25000	13200
10.	East of VC-32	2000	1100	800
11.	East of VC-31	2750	1500	400
12.	West of VC-21	12000	4800	880

SECTION B-4

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. IX-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	Truck Loading Rack	
	8" DFM	-645
	6" DFM/NSFO	-645
	Water	-440
	4" JP-5 to VC-1	-645
	4" Lube Oil #1 (abandoned)	-680
	4" Lube Oil #2 (abandoned)	-645
2.	VC-7	
	18" DFM to VC-5	-650
	12" NSFO to VC-5	-650
	6" DFM to Diesel Purification Plant	-650
	10" DFM to Diesel Purification Plant	-650
	12" NSFO to VC-1	-650
	18" DFM to VC-1	-650
	8" DFM to Loading Rack	-650
	6" DFM/NSFO to Loading Rack	-650
3.	VC-1	
	6" Multi.	
	HIRI side of Ins.	-840
	Navy side of Ins.	-640
	16" DFM from Pumphouse 59	-640

	18" JP-5 from Pumphouse 59	-640
	18" DFM from Pumphouse 59	-640
	18" DFM to VC-7	-640
	12" NSFO to VC-7	-640
	6" JP-5 to Loading Rack	-640
	4" Drain to VC-12	-620
	12" NSFO to Merry Pt.	-640
	18" DFM to Merry Pt.	-640
	4" Drain and 12" Ballast are fiberglass.	
4.	Hose Bibb/South Side	-500
5.	VC-10	
	32" Avgas to V. Docks	-640
	32" Avgas to VC-1	-640
	10" Mogas to VC-1	-640
	10" Mogas to So.	-640
6.	VC-9	
	10" NSFO to VC-8	-680
	12" NSFO to VC-8	-680
	16" DFM to VC-8	-680
7.	VC-8	
	10" NSFO	-680
	12" NSFO	-680
	16" DFM	-680
8.	Bole St. crossing	
	12" NSFO to Upper Tank Farm	-190
	12" NSFO to VC-8	-665
	16" DFM to VC-8	-665

9.	Dresser Coupling on 12" NSFO/east of Bldg. 584	
	North Side	-210
	South Side	-720
10.	VC-14	
	12" NSFO to VC-15	-620
	12" DFM to VC-32	-620
	12" DFM to VC-32	-620
11.	Test Box 94' 4" east of Bldg. 684 in Millicon Field	-790
12.	VC-32	
	6" DFM to "S" Dock	-740
	12" DFM to VC-31	-740
	8" DFM to VC-14	-740
	12" DFM to VC-14	-740
13.	Test Box North of VC-32	-670
14.	VC-31	
	12" DFM to VC-32	-620
	12" DFM to "M" Dock	-620
15.	VC-29	
	12" DFM to VC-31	-650
	12" DFM to Tunnel	-650
16.	VC-20	
	12" DFM to "M" Dock	-720
	12" NSFO to VC021	-720
	12" DFM to "B" Dock	-720
	10" C.I. Water	-560
17.	VC-21	
	12" DFM to VC-20	-650

18" NSFO to VC-34	-650
18" NSFO (abandoned)	-650

SECTION B-4

CURRENT TEST NO. 1

TABLE NO. IX-C

Location: Test Box #10, east of VC-32.

Anodes used for current test: 8 Steel rods used as temporary anodes.

Negative Connection: To existing test lead in Test Box.

Rectifier D.C. Output: 40 volts - 11.5 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Test Box east of Bldg. 684 in Millican Field	- 780	- 990	210
2.	Gas, S side of Bldg. 678			
	Above ground side of Ins.	- 580	- 700	120
	Below ground side of Ins.	-1200	-1360	160
3.	Water, S side of Bldg. 678	- 615	- 700	85
4.	VC-32			
	6" DFM to S Dock	- 775	- 920	145
	12" DFM to VC-31	- 775	- 920	145
	8" DFM to VC-14	- 775	- 920	145
	12" DFM to VC-14	- 775	- 920	145
5.	Test Box, North of VC-32	- 670	- 675	5
6.	VC-31			
	12" DFM to VC-32	- 660	- 760	100
	12" DFM to M Dock	- 660	- 760	100
7.	Water line S end of Bldg. 684	- 295	- 290	- 5*
8.	VC-29			
	12" DFM to VC-31	- 700	- 725	25
	12" DFM to Tunnel	- 700	- 725	25

9.	VC-20			
	12" DFM to M Dock	- 720	- 740	20
	12" NSFO to VC-21	- 720	- 740	20
	12" DFM to B Dock	- 720	- 740	20
	10" C.I. Water	- 560	- 555	-5*
10.	VC-21			
	12" DFM to VC-20	- 665	- 685	20
	18" NSFO to VC-34	- 665	- 685	20
	18" NSFO (abandoned)	- 665	- 685	20
11.	VC-14			
	12" NSFO to VC-15	- 640	- 680	40
	12" DFM to VC-32	- 640	- 680	40
	6" (abandoned)	- 370	- 400	30
	6" (abandoned)	- 400	- 420	20
12.	Dresser Coupling on 12" NSFO east of Bldg. 584			
	South side of dresser	- 670	- 730	60
	North side of dresser	- 215	- 215	0
13.	Bole Street Crossing			
	12" NSFO to Upper Tank Farm	- 210	- 210	0
	12" NSFO to VC-8	- 680	- 710	30
	16" DFM to VC-8	- 680	- 710	30
	6" (abandoned)	- 310	- 310	0
	6" (abandoned)	- 440	- 440	0
	Casing Vent (east to west)			
	#1	- 310	- 310	0
	#2	- 240	- 240	0
	#3	- 265	- 265	0
	#4	- 420	- 420	0
	#5	- 415	- 415	0

14.	VC-8			
	10" NSFO	- 700	- 710	10
	12" NSFO	- 700	- 710	10
	16" DFM	- 700	- 710	10
15.	VC-9			
	10" NSFO to VC-8	- 710	- 720	10
	12" NSFO to VC-8	- 710	- 720	10
	16" DFM to VC-8	- 710	- 720	10
16.	Hose bibb, South side of VC-1	- 500	- 505	5
17.	VC-1			
	6" Multi.			
	HIRI side of Ins.	- 835	- 830	-5*
	Navy side of Ins.	- 640	- 645	5
	16" DFM from Pumphouse 59	- 640	- 645	5
	18" JP-5 from Pumphouse 59	- 640	- 645	5
	18" DFM from Pumphouse 59	- 640	- 645	5
	18" DFM to VC-7	- 640	- 645	5
	12" NSFO to VC-7	- 640	- 645	5
	6" JP-5 to Loading Rack	- 640	- 645	5
	4" Drain to VC-12	- 640	- 645	5
	12" NSFO to Merry Pt.	- 640	- 645	5
	18" DFM to Merry Pt.	- 640	- 645	5
18.	VC-7			
	18" DFM to VC-5	- 670	- 675	5
	12" NSFO to VC-5	- 670	- 675	5
	6" DFM to Diesel Purification Plant	- 670	- 675	5
	10" DFM to Diesel Purification Plant	- 670	- 675	5

	12" NSFO to VC-1	- 670	- 675	5
	18" DFM to VC-1	- 670	- 675	5
	8" DFM to Loading Rack	- 670	- 675	5
	6" DFM/NSFO to Loading Rack	- 670	- 675	5
19.	Truck Loading Rack			
	8" DFM	- 670	- 675	5
	6" DFM/NSFO	- 670	- 675	5
	Water	- 670	- 675	5
	4" JP-5 to VC-1	- 670	- 675	5
20.	Bldg. 60 (VC-33) all lines	- 500	- 505	5

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION B-4

CURRENT TEST NO. 2

TABLE NO. IX-D

Location:	Test Box east of VC-32.
Anodes used for current test:	8 Steel rods used as temporary anodes.
Negative Connection:	To existing test lead in test box.
Rectifier D.C. Output:	65 volts - 23.0 amperes D,C,

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Test Box, east of Bldg. 684 in Millican Field	- 780	-1200	420
2.	Gas, south side of Bldg. 678			
	Above ground side of Ins.	- 580	- 820	240
	Below ground side of Ins.	-1210	-1550	340
3.	Water, south side of Bldg. 678	- 615	- 800	185
4.	VC-32			
	6" DFM to "S" Dock	- 775	-1060	285
	12" DFM to VC-31	- 775	-1060	285
	8" DFM to VC-14	- 775	-1060	285
	12" DFM to VC-14	- 775	-1060	285
5.	Test Box, North of VC-32	- 670	- 675	5
6.	VC-31			
	12" DFM to VC-32	- 660	- 820	160
	12" DFM to "M" Dock	- 660	- 820	160
7.	Water line, South end of Bldg. 684	- 295	- 290	-5*
8.	VC-29			
	12" DFM to VC-31	- 700	- 755	55

	12" DFM to Tunnel	- 700	- 755	55
9.	VC-20			
	12" DFM to "M" Dock	- 720	- 770	50
	12" NSFO to VC-21	- 720	- 770	50
	12" DFM to "B" Dock	- 720	- 770	50
	10" C.I. Water	- 560	- 555	-5*
10.	VC-21			
	12" DFM to VC-20	- 665	- 705	40
	18" NSFO to VC-34	- 665	- 705	40
	18" NSFO (abandoned)	- 665	- 705	40
11.	VC-14			
	12" NSFO to VC-15	- 640	- 735	95
	12" DFM to VC-32	- 640	- 735	95
	12" DFM to VC-32	- 640	- 735	95
	6" (abandoned)	- 370	- 430	60
	6" (abandoned)	- 400	- 450	50
12.	Dresser Coupling on 12" NSFO, east of Bldg. 584			
	South side of dresser	- 610	- 785	115
	North side of dresser	- 215	- 215	0
13.	Bole Street Crossing			
	12" NSFO to Upper Tank Farm	- 210	- 210	0
	12" NSFO to VC-8	- 680	- 760	80
	16" DFM to VC-8	- 680	- 760	80
	6" (abandoned)	- 310	- 310	0
	6" (abandoned)	- 440	- 440	0
	Casing Vent (east to west)			
	#1	- 310	- 310	0

	#2	- 240	- 240	0
	#3	- 265	- 265	0
	#4	- 420	- 420	0
	#5	- 415	- 415	0
14.	VC-8			
	10" NSFO	- 700	- 720	20
	12" NSFO	- 700	- 720	20
	16" DFM	- 700	- 720	20
15.	VC-9			
	10" NSFO to VC-8	- 710	- 730	20
	12" NSFO to VC-8	- 710	- 730	20
	16" DFM to VC-8	- 710	- 730	20
16.	Hose Bibb, south side of VC-1	- 500		
17.	VC-1			
	6" Multi.			
	HIRI side of Ins.	- 835	- 820	-15*
	Navy side of Ins.	- 640	- 650	10
	16" DFM from Pumphouse 59	- 640	- 650	10
	18" JP-5 from Pumphouse 59	- 640	- 650	10
	18" DFM from Pumphouse 59	- 640	- 650	10
	18" DFM to VC-7	- 640	- 650	10
	12" NSFO to VC-7	- 640	- 650	10
	6" JP-5 to Loading Rack	- 640	- 650	10
	4" Drain to VC-12	- 640	- 650	10
	12" NSFO to Merry Pt.	- 640	- 650	10
	18" DFM to Merry Pt.	- 640	- 650	10
18.	VC-7			
	18" DFM to VC-5	- 670	- 675	5

	12" NSFO to VC-5	- 670	- 675	5
	6" DFM to Diesel Purification Plant	- 670	- 675	5
	10" DFM to Diesel Purification Plant	- 670	- 675	5
	12" NSFO to VC-1	- 670	- 675	5
	18" DFM to VC-1	- 670	- 675	5
	8" DFM to Loading Rack	- 670	- 675	5
	6" DFM/NSFO to Loading Rack	- 670	- 675	5
19.	Truck Loading Rack			
	8" DFM	- 670	- 675	5
	6" DFM/NSFO	- 670	- 675	5
	Water	- 440	- 445	5
	4" JP-5 to VC-1	- 670	- 675	5
20.	Bldg. 60 (VC-33) all lines	- 500	- 510	10

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION B-4

CURRENT TEST NO. 3

TABLE NO. IX-E

Location:	VC-21.
Anodes used for current test:	Fourteen steel rods, two posts and short section of fence as a temporary anode bed.
Negative Connection:	8" NSFO to Lower Tank Farm.
Rectifier D.C. Output:	37 volts - 22 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Test Box, east end of Bldg. 684 in Millican Field	- 780	- 840	60
2.	Gas, south side of Bldg. 678			
	Above ground side of Ins.	- 580	- 630	50
	Below ground side of Ins.	-1200	-1230	30
3.	Water, south side of Bldg. 678	- 615	- 660	45
4.	VC-32			
	6" DFM to "S" Dock	- 775	- 825	50
	12" DFM to VC-31	- 775	- 825	50
	8" DFM to VC-14	- 775	- 825	50
	12" DFM to VC-14	- 775	- 825	50
5.	Test Box, North of VC-32	- 670	- 675	5
6.	VC-31			
	12" DFM to VC-32	- 660	- 720	60
	12" DFM to "M" Dock	- 660	- 720	60
7.	Water line south end of Bldg. 684	- 295	- 720	425
8.	VC-29			
	12" DFM to VC-31	- 700	- 780	80

	12" DFM to Tunnel	- 700	- 780	80
9.	VC-20			
	12" DFM to "M" Dock	- 720	- 840	120
	12" NSFO to VC-21	- 720	- 840	120
	12" DFM to "B" Dock	- 720	- 840	120
	10" C.I. Water	- 560	- 560	0
10.	VC-21			
	12" DFM to "M" Dock	- 665	- 925	260
	18" NSFO to VC-34	- 665	- 925	260
	18" NSFO to VC-32 (abandoned)	- 665	- 925	260
11.	VC-14			
	12" NSFO to VC-15	- 640	- 685	45
	12" DFM to VC-32	- 640	- 685	45
	12" DFM to VC-32	- 640	- 685	45
	6" (abandoned)	- 370	- 405	35
	6" (abandoned)	- 370	- 400	30
12.	Dresser Coupling on 12" NSFO, east of Bldg. 584			
	South side of dresser	- 670	- 715	45
	North side of dresser	- 215	- 210	-5*
13.	Bole Street Crossing			
	12" NSFO to Upper Tank Farm	- 210	- 205	-5*
	12" NSFO to VC-8	- 680	- 720	40
	16" DFM to VC-8	- 680	- 720	40
	6" (abandoned)	- 310	- 315	5
	6" (abandoned)	- 440	- 445	5
	Casing Vent (east to west)			
	#1	- 310	- 305	-5*

	#2	- 240	- 235	-5*
	#3	- 265	- 260	-5*
	#4	- 420	- 415	-5*
	#5	- 415	- 410	-5*
14.	VC-8			
	10" NSFO	- 700	- 730	30
	12" NSFO	- 700	- 730	30
	16" DFM	- 700	- 730	30
15.	VC-9			
	10" NSFO to VC-8	- 710	- 730	20
	12" NSFO to VC-8	- 710	- 730	20
	16" DFM to VC-8	- 710	- 730	20
16.	Hose Bibb, south side of VC-1	- 500	- 505	5
17.	VC-1			
	6" Multi.			
	HIRI side of Ins.	- 835	- 830	-5*
	Navy side of Ins.	- 640	- 655	15
	16" DFM from Pumphouse 59	- 640	- 655	15
	18" DFM from Pumphouse 59	- 640	- 655	15
	18" JP-5 from Pumphouse 59	- 640	- 655	15
	18" DFM to VC-7	- 640	- 655	15
	12" NSFO to VC-7	- 640	- 655	15
	6" JP-5 to Loading Rack	- 640	- 655	15
	4" Drain to VC-12	- 640	- 655	15
	12" NSFO to Merry Pt.	- 640	- 655	15
	18" DFM to Merry Pt.	- 640	- 655	15
18.	VC-7			
	18" DFM to VC-5	- 670	- 680	10

	12" NSFO to VC-5	- 670	- 680	10
	6" DFM to Diesel Purification Plant	- 670	- 680	10
	10" DFM to Diesel Purification Plant	- 670	- 680	10
	12" NSFO to VC-1	- 670	- 680	10
	18" DFM to VC-1	- 670	- 680	10
	8" DFM to Loading Rack	- 670	- 680	10
	6" DFM/NSFO to Loading Rack	- 670	- 680	10
19.	Truck Loading Rack			
	8" DFM	- 670	- 680	10
	6" DFM/NSFO	- 670	- 680	10
	Water	- 440	- 440	0
	4" JP-5 to VC-1	- 670	- 680	10
20.	Bldg. 60 (VC-33) all lines	- 500	- 520	20

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION B-4

CONTINUITY TEST NO. 5

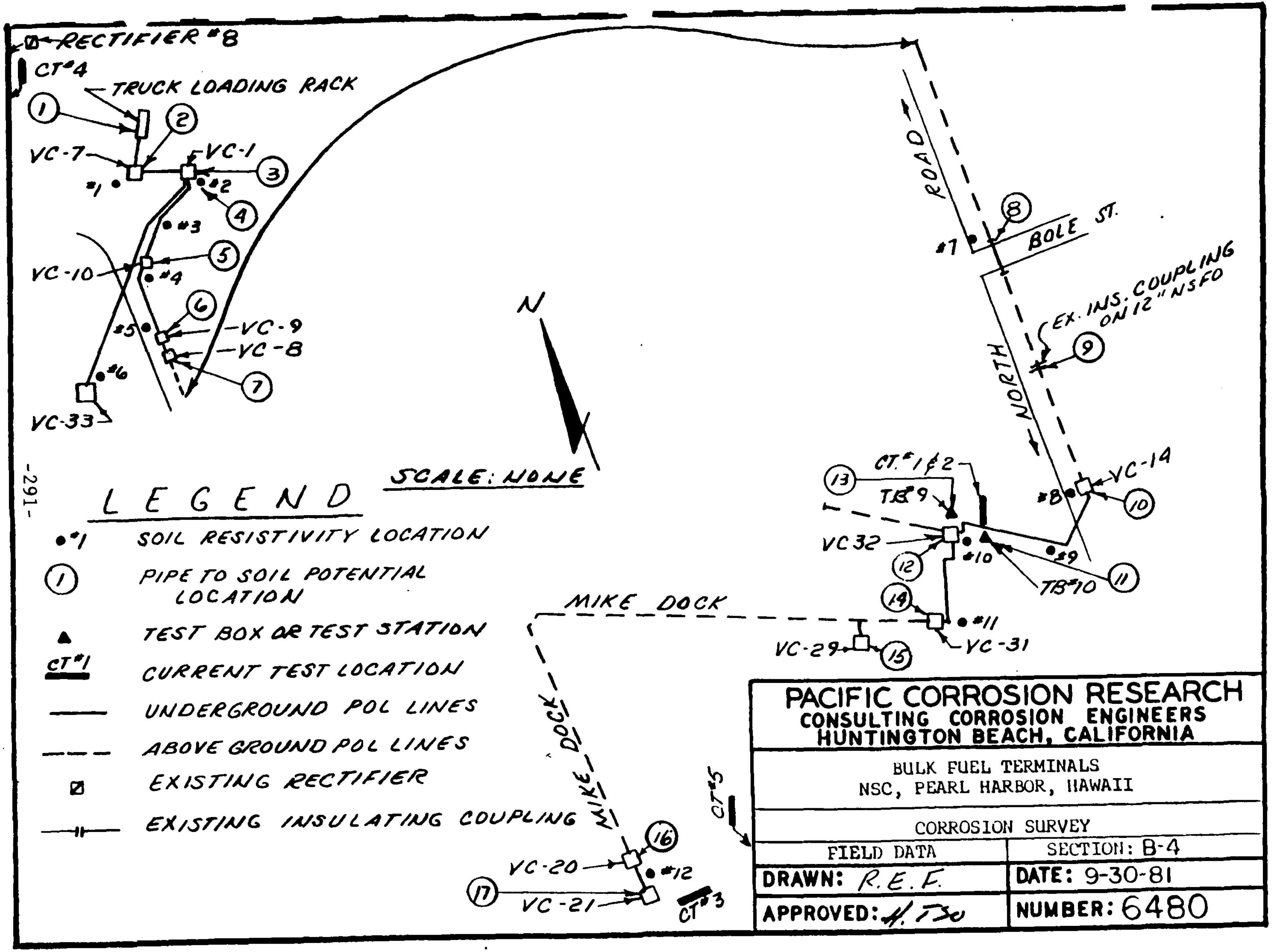
TABLE NO. IX-F

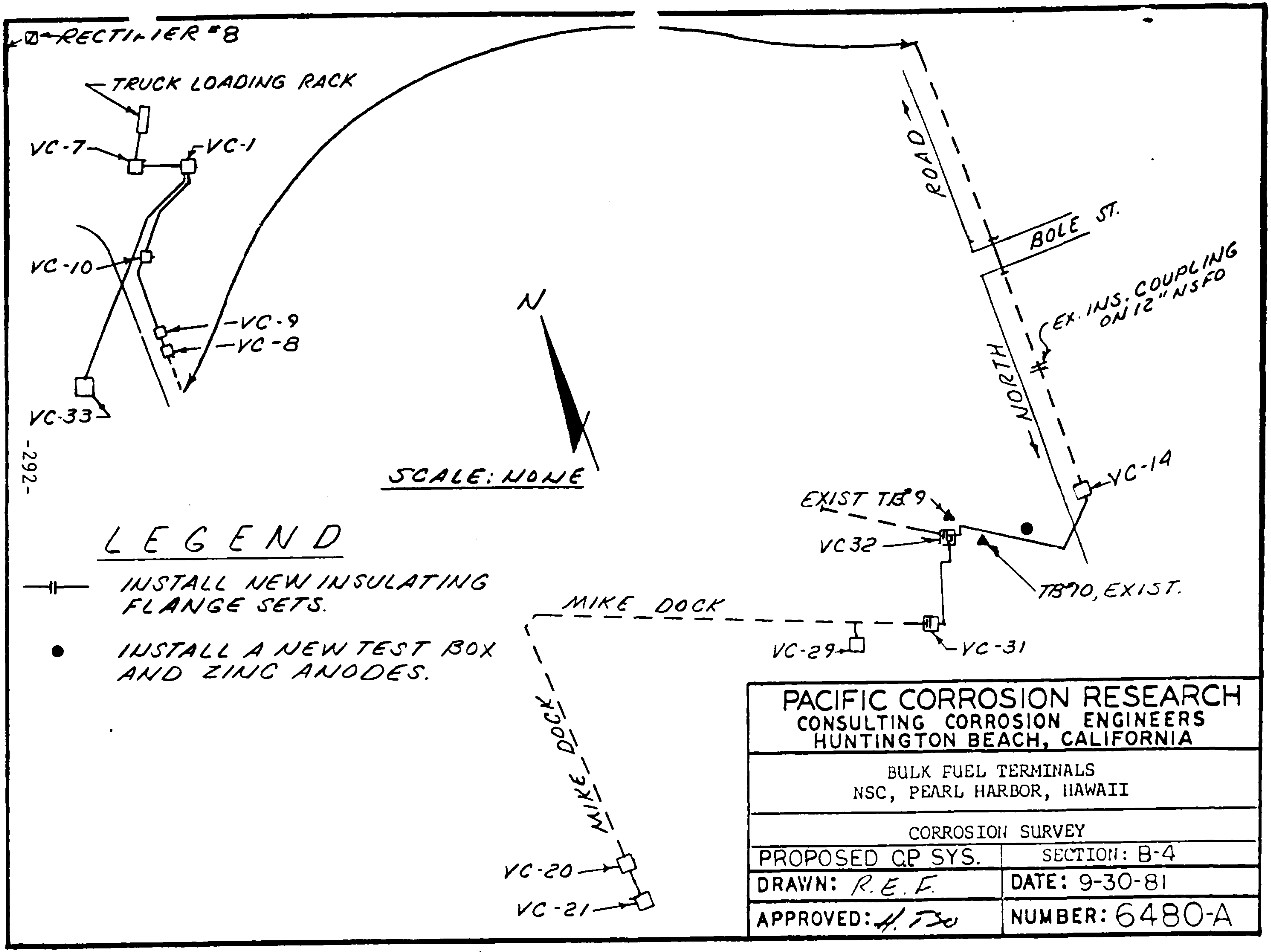
Location:	NW corner of Bldg. 553, existing Rectifier #9.
Anodes used for current test:	Nine existing 3"x60" graphite anodes.
Negative Connection:	18" NSFO line.
Rectifier D.C. Output:	50 volts - 9 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC-22 8" NSFO (Sec. B-6)	-625	-650	25
2.	VC-21 8" NSFO (Sec. B-6)	-625	-650	25
	18" NSFO (Sec. B-6)	-625	-650	25
	12" NSFO (Sec. B-6)	-625	-650	25
3.	VC-20 12" DFM (Sec. B-4)	-610	-670	60
	12" NSFO (Sec. B-4)	-610	-670	60
	10" Water C.I.	-525	-520	-5*
4.	VC-34, 3-10" lines to Middle Tank Farm (Sec. B-6 & B-7)	-645	-670	25
	18" NSFO (Sec. B-6)	-645	-670	25
	8" DFM (Sec. B-6)	-645	-670	25
5.	Gas, SOV, SE of Bldg. 186	-665	-660	-5*
6.	VC-15 12" NSFO (Sec. B-6)	-560	-585	25
	18" NSFO (Sec. B-6)	-560	-585	25
	18" NSFO (Sec. B-6)	-560	-585	25
7.	VC-14 12" NSFO (Sec. B-6)	-560	-580	20
	12" DFM (Sec. B-4)	-560	-580	20
	12" DFM (Sec. B-4)	-560	-580	20

8.	Bole Road Crossing			
	12" NSFO (Sec. B-6)	-190	-180	-10*
	12" NSFO (Sec. B-4)	-635	-665	30
	16" DFM (Sec. B-4)	-635	-665	30
9.	VC-32			
	6" DFM (Sec. B-4)	-690	-725	35
	12" DFM (Sec. B-4)	-690	-725	35
	8" DFM (Sec. B-4)	-690	-725	35
	12" DFM (Sec. B-4)	-690	-725	35
10.	Test Box North of VC-32	-820	-815	-5*
11.	VC-29 12" DFM (Sec. B-4 & B-2)	-660	-710	50

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.


RECTIFIER #8
CT#4
TRUCK LOADING RACK
VC-7
VC-1
VC-10
VC-9
VC-8
VC-33
#1
#2
#3
#4
#5
#6
N
SCALE: NONE
ROAD
BOLE ST.
#7
EX. INS. COUPLING ON 12" NSFO
NORTH
VC-14
#8
#9
CT.#1 & 2
TB#9
VC 32
#10
TB#10
#11
VC-31
VC-29
MIKE DOCK
MIKE DOCK
CT#5
VC-20
VC-21
#12
CT#3
LEGEND
•#1 SOIL RESISTIVITY LOCATION
(1) PIPE TO SOIL POTENTIAL LOCATION
▲ TEST BOX OR TEST STATION
CT#1 CURRENT TEST LOCATION
UNDERGROUND POL LINES
ABOVE GROUND POL LINES
EXISTING RECTIFIER
EXISTING INSULATING COUPLING
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA
BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII
CORROSION SURVEY
FIELD DATA
SECTION: B-4
DRAWN: R.E.F.
DATE: 9-30-81
APPROVED: H. Tsu
NUMBER: 6480


RECTIFIER #8
TRUCK LOADING RACK
VC-7
VC-1
VC-10
VC-9
VC-8
VC-33
N
SCALE: NONE
ROAD
BOLE ST.
NORTH
EX. INS. COUPLING ON 12" NSFO
VC-14
EXIST TB 9
VC 32
TB 70, EXIST.
MIKE DOCK
VC-29
VC-31
MIKE DOCK
VC-20
VC-21
LEGEND
INSTALL NEW INSULATING FLANGE SETS.
INSTALL A NEW TEST BOX AND ZINC ANODES.
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA
BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII
CORROSION SURVEY
PROPOSED CP SYS.
SECTION: B-4
DRAWN: R.E.F.
DATE: 9-30-81
APPROVED:
NUMBER: 6480-A

SECTION B-5

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE LINES FROM VC-1 TO THE UPPER TANK FARM

SECTION B-5

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE LINES FROM VC-1 TO THE UPPER TANK FARM

SECTION B-5

SUMMARY

1. Conclusions:

   A. The soil environment in Section B-5 can be classified as an area of moderate to severe corrosion potential.

   B. The POL lines of Section B-5 are not at a protective potential level, with all potentials below -700 mv.

   C. The POL lines are electrically continuous with each other from VC-1 to the Upper Tank Farm.

   D. An insulator was found installed above ground on the 12" NSFO line across the street from Building 584. The 12" NSFO line from Tank #53 is not electrically continuous with the 12" NSFO line to VC-13, due to the installation of the insulator at this location.

   E. Approximately 8,000 sq. ft. of coated steel POL lines are to be considered for cathodic protection. A protective current of 20 amperes D.C. will be required to provide a protective potential for the line.

   F. Rectifiers #8 and #9 do not provide adequate protective current for this section of POL lines.

   G. The cast iron fire water mains around the Upper Tanks are not electrically continuous section to section. These cast iron water mains are also electrically discontinuous with the POL lines.

2. Recommendations:

   A. The results of the field data obtained indicates the current demand for the underground POL lines will require a new anode bed to provide protection for Section B-5. It is recommended that this anode bed consisting of one new oil cooled rectifier and fourteen (14) 4"x40" graphite anodes, be installed southwest of Pumphouse 59.

B. It is recommended that the cast iron fire water mains around the Upper Tank Farm be bonded across each joint with a No. 8 TW stranded copper cable. A resistance bond station should be installed between the cast iron fire water main and the POL lines near Fire Hydrant #468.

C. It is recommended that an insulator be installed at each of the following locations:

(1) 18" JP-5 line from Tank #55 in the concrete tunnel NW of Tank #1226.

(2) POL lines to Tanks #1224, #1225, #1226 and #1227 in concrete tunnel.

(3) 12" JP-5 line from Tank #55 above ground outside the Pump Central Building.

D. A continuity bond should be made across the existing insulator on the 12" NSFO line across the street fromBuilding 584.

SECTION B-5

POL LINES INSIDE THE PEARL HARBOR COMPLEX INCLUDING THE LINES FROM

VC-1 TO THE UPPER TANK FARM

1. Description.

A. Lines to be Protected:

(1) From VC-1 to Purification Plant

a. 4" Drain Line - Fiberglass

b. 12" Ballast Line - Fiberglass

c. 4" Drain Line - Fiberglass

(2) From VC-1 to Diesel Tank S768 and S767

a. 4" Diesel Line - Coated Steel

(3) Purification Plant

a. POL lines - Coated Steel

b. Oil, waste, drain and Ballast Lines - Fiberglass

(4) From Pumphouse 59 to Four Underground Steel Tanks (1224, 1225, 1226 and 1227)

a. POL line in concrete tunnel

(5) From Tank S769 to Four Underground Steel Tanks (1224, 1225, 1226 and 1227)

a. 12" Vent Pipe - Coated Steel

b. 3 - 18" Vent Pipes - Coated Steel

(6) From Tank 55 to Pumphouse 59

a. 18" JP-5 Line - Coated Steel

b. 12" JP-5 Line - Coated Steel

(7) Tank 48 (S756) to Purification Plant

a. 8" Ballast Line - Coated Steel

(8) Tank 48 (S756) to VC-9

a. 10" NSFO Line - Coated Steel

(9) From VC-8 to Tank 47 (S755) and 54 (S762)

a. 12" DFM Line - Coated Steel

(10) From VC-8 to Tank 46 (S754)

a. 12" DFM Line - Coated Steel

(11) From VC-13 to Tank 53 (S761)

a. 12" NSFO Line - Coated Steel

B. Existing Cathodic Protection System:

No Cathodic protection system is installed in this section. The POL lines are to be protected by existing Rectifier #8.

2. Field Data and Evaluation of Data.

A. Soil Resistivity Measurements: A total of sixteen sets of soil resistivity measurements were obtained at representative locations throughout the Upper Tank Farm area as shown in Table No. X-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	31	Severe
Medium	2,000 - 10,000	65	Moderate
High	10,000 - 30,000	4	Slight unless other factors are pronounced
Very High	Above - 30,000	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on the underground metallic structures. Thirty-one percent of the measurements obtained were in the severe category and sixty-five percent were in the medium or moderate category.

B. "As Found" Pipe-to-Soil Potentials: "As Found" pipe-to-soil potentials were obtained at each valve chamber, each tank and at the point where the pipelines enter underground. The results of these measurements indicated that POL lines of Section B-5 are not at a protective potential level. The results of these measurements are shown in Table No. X-B.

C. Current Tests: Four current tests were conducted on the POL lines of Section B-5. Pipe-to-soil potentials were obtained at the same locations as the "as found" potentials. Measurements were obtained with the test rectifier "off" and "on".

(1) Current Test No. 1 - This current test was conducted in the area between Tank 47 and 48. Nineteen steel rods were installed 50' southeast of Tank 48 as a temporary anode bed. The negative from a test rectifier was connected to the 12" DFM line at VC-9. The current used for this test was 20 amperes D.C.. The results of this test are shown in Table No. X-C.

(2) Current Test No. 2 - This test was conducted with the same anode configuration and negative connection as Current Test No. 1. The current was increased to 34 amperes D.C.. The results of this test are shown in Table No. X-D.

(3) Current Test No. 3 - This test was conducted in the area west of the four underground tanks and Pumphouse 59. The negative from the test rectifier was connected to the 12" JP-5 line outside the Pumphouse Control Building. Twelve steel rods were installed north of the Fire Foam Pumphouse 1613 as a temporary anode bed. The current used for this test was 10 amperes D.C.. The results of this test are shown in Table No. X-F.

(4) Current Test No. 4 - This current test was conducted as a continuity test. Pipe-to-soil potentials were obtained at representative locations of Section B-5. Potentials were obtained with the existing Rectifier #8 turned "off" and "on". The results of this test are shown in Table No. VI-E, Section B-1.

Based on the data obtained from these tests, the following conclusions are made:

a. POL lines of Section B-5 are electrically continuous with the POL lines of Section B-1 thru B-9.

b. An insulator was found installed on the 12" NSFO line above ground across the street from Building 584. The 12" NSFO line from Tank 53 is not electrically continuous with the fuel piping system.

c. Rectifier #8 does not provide adequate protection for this section.

d. The current demand for the POL lines of Section B-5 will be high.

e. The cast iron water main around the tanks is not electrically continuous with the POL lines.

D. Inspection of Pipelines: The underground POL lines of Section B-5 are coated steel. The POL lines installed above ground are covered with light green protective paint. The coating appears in good condition. The POL lines to the Lube Tanks 1 and 2 were disconnected from each of these two tanks. We were advised by Mr. Kimi that these two tanks were abandoned.

E. Leak History: The leak history was discussed with Mr. John Kimi, Mr. Edwin Katada and Mr. Albert Wong of the Base Fuel Department. No leaks were recorded on this section of POL lines.

3. Conclusions.

Based on the field data obtained, the following is submitted:

A. Soil resistivity measurements indicated that 31% of the readings are in the severe category and 65% are in the moderate category. The environment in Section B-5 can be classified as an area of moderate to severe corrosion potential.

B. The POL lines of Section B-5 are not at a protective potential level with all potentials below -700 mv.

C. The POL lines are electrically continuous with each other from VC-1 to the Upper Tank Farm.

D. An insulator was found installed above ground on the 12" NSFO line across the street from Building 584. The 12" NSFO line from Tank 53 is not electrically continuous with

the 12" NSFO line to VC-13 due to the installation of the insulator at this location.

E. The results of current tests conducted indicated that current demand for Section B-5 will be high. Approximately 8,000 sq. ft. of coated steel POL lines are to be considered for cathodic protection. A protective current of 20 amperes D.C. will be required to provide a protective potential for the line.

F. Rectifiers #8 and #9 do not provide adequate protective current for this section of POL lines.

G. The cast iron fire water mains around the Upper Tanks are not electrically continuous section to section. These cast iron water mains are also electrically discontinuous with the POL lines.

H. Inspection of POL pipelines above ground indicated that the coating of these pipelines is in good condition.

4. Recommendations.

A. The results of the field data obtained indicated that the current demand for the underground POL lines will require a new anode bed to provide protection for Section B-5. It is recommended that this anode bed consisting of one new oil cooled rectifier and fourteen 4"x40" graphite anodes be installed southwest of Pumphouse 59. An anode watering system should be installed along with this anode bed.

B. The cast iron fire mains were found to be electrically discontinuous from section to section during this survey. It is recommended that the cast iron fire water mains around the Upper Tank Farm be bonded across each joint with a No.

8 TW stranded copper cable. A resistance bond station should be installed between the cast iron fire water main and the POL lines near Fire Hydrant #469.

C. It is recommended that an insulator be installed at each of the following locations:

   (1) 18" JP-5 line from Tank 55 in the concrete tunnel NW of Tank #1226.

   (2) POL lines to Tanks #1224, #1225, #1226 and #1227 in concrete tunnel.

   (3) 12" JP-5 line from Tank 55 above ground outside the Pump Central Building.

D. A continuity bond should be made across the existing insulator on the 12" NSFO line across the street from Building 584.

NOTE: The locations of pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No. 6481.

The recommended C.P. system for Section B-5 is shown on PCR Drawing No. 6481-A.

NAVFAC 11013/7 (1 78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM CORROSION SURVEY, SECTION B-5

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
OIL COOLED RECTIFIERS	1	ea	1950.00	1950.00	600.00	600.00	2550.00	2550.00
4"x40" GRAPHITE ANODES	14	ea	210.00	2940.00	150.00	2100.00	360.00	5040.00
COAL COKE BREEZE	4200	lb	0.30	1260.00	0.08	336.00	0.38	1596.00
#4 HMP STRANDED COPPER CABLE	450	ft	1.20	540.00	0.15	67.50	1.35	607.50
1" PVC CLASS 200, PLASTIC PIPE	600	ft	0.75	450.00	0.15	90.00	0.90	540.00
INSULATING FLANGE SETS	6	ea	45.00	270.00	75.00	450.00	120.00	720.00
SPLIT BOLTS	20	ea	1.05	21.00	4.50	90.00	5.55	111.00
CONCRETE TEST BOX/CAST IRON LIDS	2	ea	45.00	90.00	75.00	150.00	120.00	240.00
HOSE CONNECTION ADAPTERS	1	ea	7.50	7.50	7.50	7.50	15.00	15.00
0.01 OHM SHUNT	1	ea	7.50	7.50	7.50	7.50	15.00	15.00
RESISTANCE BOND STATION	1	ea	150.00	150.00	150.00	150.00	300.00	300.00
CONCRETE PAD	1	ea	150.00	150.00	300.00	300.00	450.00	450.00
COAL TAR ENAMEL (1 GALLON CAN)	1	ea	22.50	22.50	45.00	45.00	67.50	67.50
BUTYL TAPE	2	rl	37.50	75.00	450.00	90.00	82.50	165.00
RUBBER TAPE	6	rl	4.50	27.00	7.50	45.00	12.00	72.00
PLASTIC TAPE	6	rl	4.50	27.00	7.50	45.00	12.00	72.00
TERRA TAPE	500	ft	0.22	110.00	0.08	40.00	0.30	150.00

S/N 0105-LF-010-1335

★ G P O : 1979-689-016/4302

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 2 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION B-5

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
ALUMINO-THERMIC WELDS	10	ea	3.00	30.00	37.50	375.00	40.50	405.00
TRENCH	450	ft	-	-	4.50	2025.00	4.50	2025.00
BONDING OF CAST IRON PIPE	3200	ft	3.00	9600.00	10.50	33600.00	13.50	43200.00
SUBTOTAL				17727.50		40613.50		58341.00
10% MISC. MATERIALS & LABOR				1772.75		4061.35		5834.10
SUBTOTAL				19500.25		44674.85		64175.10
30% CONSTRUCTION PROFIT				5850.07		13402.45		19252.52
TOTAL				25350.32		58077.30		83427.62

S/N 0105-LF-010-1335
★ G.P.O.: 1979-689-016/4302

SECTION B-5

SOIL RESISTIVITIES

TABLE NO. X-A

Rdg. No.	Location	Soil Resistivity (ohm-cms) Depth 2.5'	5'	10'
1.	West of Tank 53	11500	6800	5200
2.	West of Tank 53, near fence	13000	7300	4200
3.	West of Tank 46	2600	1900	3000
4.	West of Tank 46, near fence	6000	3000	3200
5.	North of Tank 46	3300	4000	3200
6.	West of Tank 47	4050	4200	2800
7.	NE of Tank 47	8000	5300	4000
8.	NW of Tank 54	5000	2500	2400
9.	200' NW of Rdg. #8	8500	4000	2000
10.	North of Tank 55	2200	1800	2600
11.	SW of Tank 48	550	540	1080
12.	East of VC-8	1000	1200	1200
13.	200' North of VC-11	10000	6100	5200
14.	South of S-769	6000	2000	820
15.	Between Tanks S-770 & S-769	2000	1500	640
16.	East of Float'N Tank	2700	3000	1180

SECTION B-5

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. X-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	Tank 53, 12" NSFO	-180
2.	12" NSFO, 120' W of Tank 53	-175
3.	Two 6" lines near Rdg. #2	-415
4.	Tank 46, 12" DFM	-655
5.	F.H. #467, W of Tank 46	-480
6.	Tank 47	-375
7.	F.H. #468, NW of Tank 47	-490
8.	F.H. #472, SE of Tank 54	-420
9.	Tank 54, 12" DFM	-615
10.	F.H. #471, SE of Tank 55	-440
11.	Tank 55, 10" Water	-670
12.	Tank 55, 18" JP-5	-670
13.	Tank 55, 12" JP-5	-670
14.	Tank 48, 10" NSFO	-620
15.	Tank 45, 12" Ballast	-620
16.	Tank 45, 8" Ballast	-620
17.	Tank S-769, 10" Line	-600
18.	Two 4" Ballast Lines, Tank S-769	-600
19.	Tank S-770, 8" Ballast	-570
20.	Tank S-770, 2-4" Ballast	-570
21.	Tank, five lines North of Tank 2 12" Ballast fiberglass.	-

	4" U.G. Sump	-480
	4" HALWA Sump fiberglass.	-
	4" from loading rack fiberglass.	-
22.	12" Ballast line in Pit, SE of Tank S-769	-610
23.	Float'n Tank, 8" Ballast line and 4" Ballast Line	-600
24.	Sett'g Tank	-680
25.	Separators (North)	-610
26.	Separators (South)	-620
27.	VC-12	
	8" Ballast to S-770	-640
	4" Slop line to loading rack	-640
	8" Ballast to S-769	-640
	4" Ballast to U.G. Sump	-640
	8" Ballast to VC-11	-640
	4" Suction to Sump	-640
28.	VC-11	
	8" Ballast to VC-12	-610
	8" Ballast to Tank 48	-610

SECTION B-5

CURRENT TEST NO. 1

TABLE NO. X-C

Location: East of VC-11, NW of Tank 47.

Anodes used for current test: Nineteen steel rods used as temporary anodes.

Negative Connection: To 12" DFM at VC-9.

Rectifier D.C. Output: 90 volts - 20 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank 53, 12" NSFO	-210	-250	40
2.	12" NSFO, 120' W of Tank 53 near fence	-265	-470	205
3.	Two 6" lines near Rdg. #2	-430	-455	25
4.	Tank 46, 12" DFM	-635	-675	40
5.	F.H. #467, W of Tank 46	-500	-505	5
6.	Tank 47, 12" DFM	-565	-710	145
7.	F.H. #468, NW of Tank 47	-500	-550	10
8.	F.H. #472, SW of Tank 54	-365	-385	20
9.	Tank 54, 12" DFM	-625	-710	85
10.	F.H. #471, SE of Tank 55	-445	-455	10
11.	Tank 55, 10" Water	-680	-755	75
12.	Tank 55, 18" JP-5	-680	-755	75
13.	Tank 55, 12" JP-5	-680	-755	75
14.	Tank 48, 10" NSFO	-610	-750	140
15.	Tank 45, 12" Ballast	-545	-555	10
16.	Tank 45, 8" Ballast	-545	-555	10
17.	Tank S-769, 10" Line	-610	-660	50

18.	Two 4" Ballast Lines, Tank S-769	-610	-660	50
19.	Tank S-770, 8" Ballast	-610	-660	50
20.	Tank S-770, 2-4" Ballast	-610	-660	50
21.	Tank, five lines North of Tank			
	4" U.G. Sump	-685	-715	30
	4" from loading rack	-685	-715	30
22.	12" Ballast line in pit SE of Tank S-769	-610	-715	30
23.	Float'n Tank, 8" Ballast line and 4" Ballast line	-630	-670	40
24.	Settl'g Tank	-630	-670	40
25.	Separator (North)	-630	-670	40
26.	Separator (South)	-630	-670	40
27.	VC-12			
	8" Ballast to S-770	-620	-635	15
	4" Slop line to loading rack	-620	-635	15
	8" Ballast to S-769	-620	-635	15
	4" Ballast to U.G. Sump	-620	-635	15
	8" Ballast to VC-11	-620	-635	15
	4" Suction to Sump	-620	-635	15
28.	VC-7 (all lines)	-660	-670	10
29.	VC-9	-680	-820	140
30.	VC-14	-685	-715	30

SECTION B-5

CURRENT TEST NO. 2

TABLE NO. X-D

Location: East of VC-11, NW of Tank 47.

Anodes used for current test: Nineteen steel rods and a short section of fence used as temporary anodes.

Negative Connection: To 12" DFM at VC-9.

Rectifier D.C. Output: 83 volts - 34 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank 53, 12" NSFO	-210	-280	70
2.	12" NSFO, 120' W of Tank 53, near fence	-265	-640	335
3.	Two 6" lines near Rdg. #2	-430	-470	40
4.	Tank 46, 12" DFM	-635	-710	75
5.	F.H. #467, W of Tank 46	-500	-510	10
6.	Tank 47, 12" DFM	-565	-810	245
7.	F.H. #468, NW of Tank 47	-500	-475	-25*
8.	F.H. #472, SW of Tank 54	-365	-360	- 5*
9.	Tank 54, 12" DFM	-625	-770	145
10.	F.H. #471, SE of Tank 55	-445	-465	20
11.	Tank 55, 10" Water	-680	-805	125
12.	Tank 55, 18" JP-5	-680	-805	125
13.	Tank 55, 12" JP-5	-680	-805	125
14.	Tank 48, 10" NSFO	-610	-850	240
15.	Tank 45, 12" Ballast	-545	-560	15
16.	Tank 45, 8" Ballast	-545	-560	15
17.	Tank S-769, 10" Line	-610	-680	70

18.	Two 4" Ballast Lines, Tank S-769	-610	-680	70
19.	Tank S-770, 8" Ballast	-610	-680	70
20.	Tank S-770, 2-4" Ballast	-610	-680	70
21.	Tank, five lines north of Tank			
	4" U.G. Sump	-685	-735	70
	4" from loading rack	-685	-735	70
22.	12" Ballast line in pit SE of Tank S-769	-610	-685	75
23.	Float'n Tank, 8" Ballast line & 4" Ballast Line	-630	-685	55
24.	Settl'g Tank	-630	-685	55
25.	Separator (north)	-630	-685	55
26.	Separator (south)	-630	-685	55
27.	VC-12			
	8" Ballast to S-770	-620	-645	25
	4" Slop line to loading rack	-620	-645	25
	8" Ballast to S-769	-620	-645	25
	4" Ballast to U.G. Sump	-620	-645	25
	8" Ballast to VC-11	-620	-645	25
	4" Suction to Sump	-620	-645	25
28.	VC-7 (all lines)	-660	-685	25
29.	VC-9	-680	-915	235
30.	VC-14	-685	-735	50

SECTION B-5

CURRENT TEST NO. 3

TABLE NO. X-F

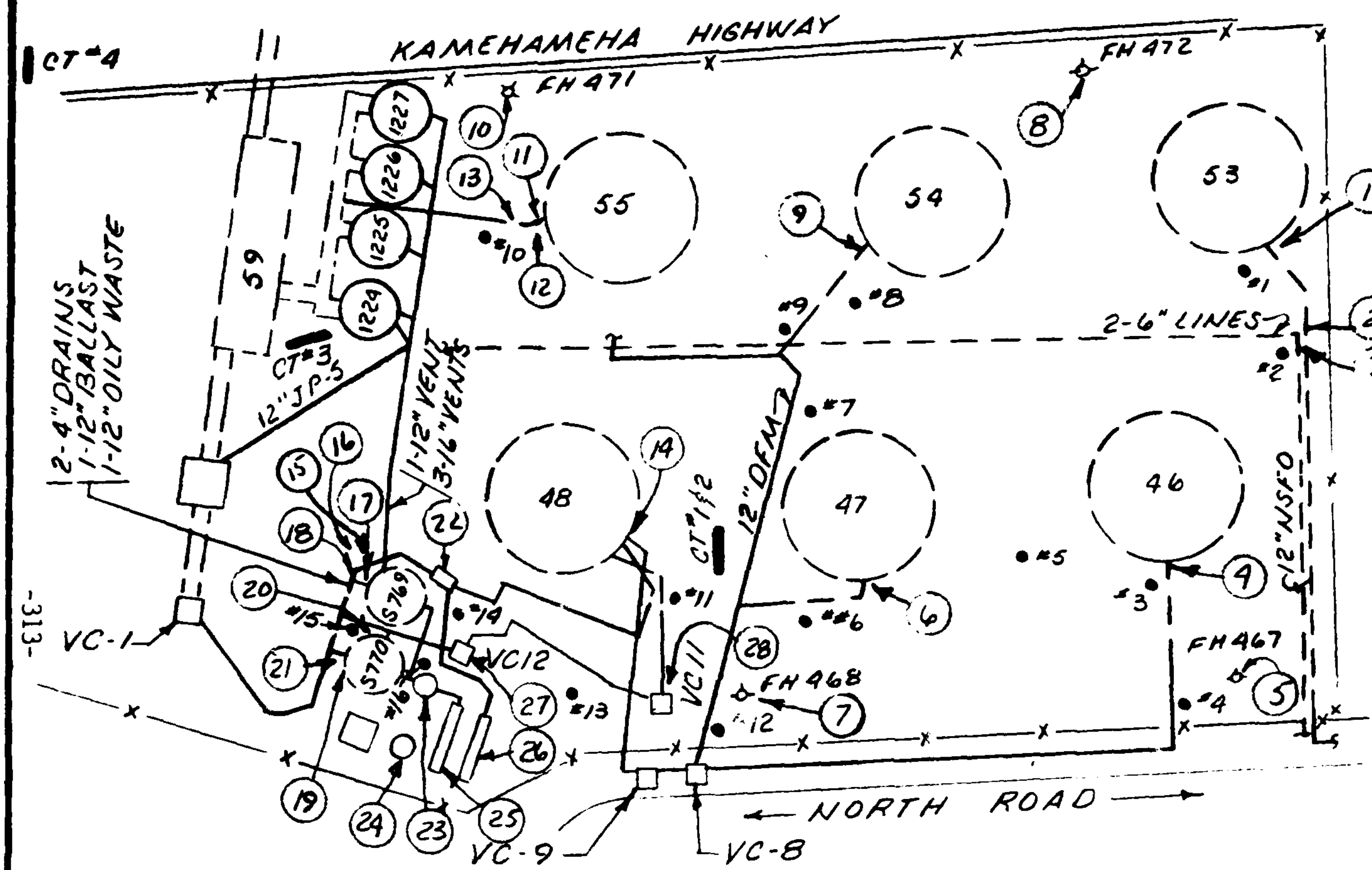
Location: 14" JP-5 Line at Bldg. 59.

Anodes used for current test: New anode bed consisting of 12 steel rods installed north of Bldg. 1613.

Negative Connection: 14" JP-5 line at Bldg. 59.

Rectifier D.C. Output: 10 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank 768, E. side	-790	-830	40
2.	Tank 767, W. side	-810	-850	40
3.	Tank L2 (765), E. side	-525	-510	-15*
4.	Tank L1 (764), W. side	-460	-455	- 5*
5.	Tank S770, N. side	-590	-615	25
6.	Tank S769, N. side	-600	-650	50
7.	Tank 48, N. side	-660	-700	40
8.	Tank 55, N. side	-710	-735	25
9.	Settling Tank, N. side	-680	-710	30
10.	Float'n Tank, N. side	-600	-650	50
11.	10" NSFO line at VC-9	-680	-715	35
12.	POL lines in VC-1	-600	-640	40
13.	F.H. #469	-440	-450	10



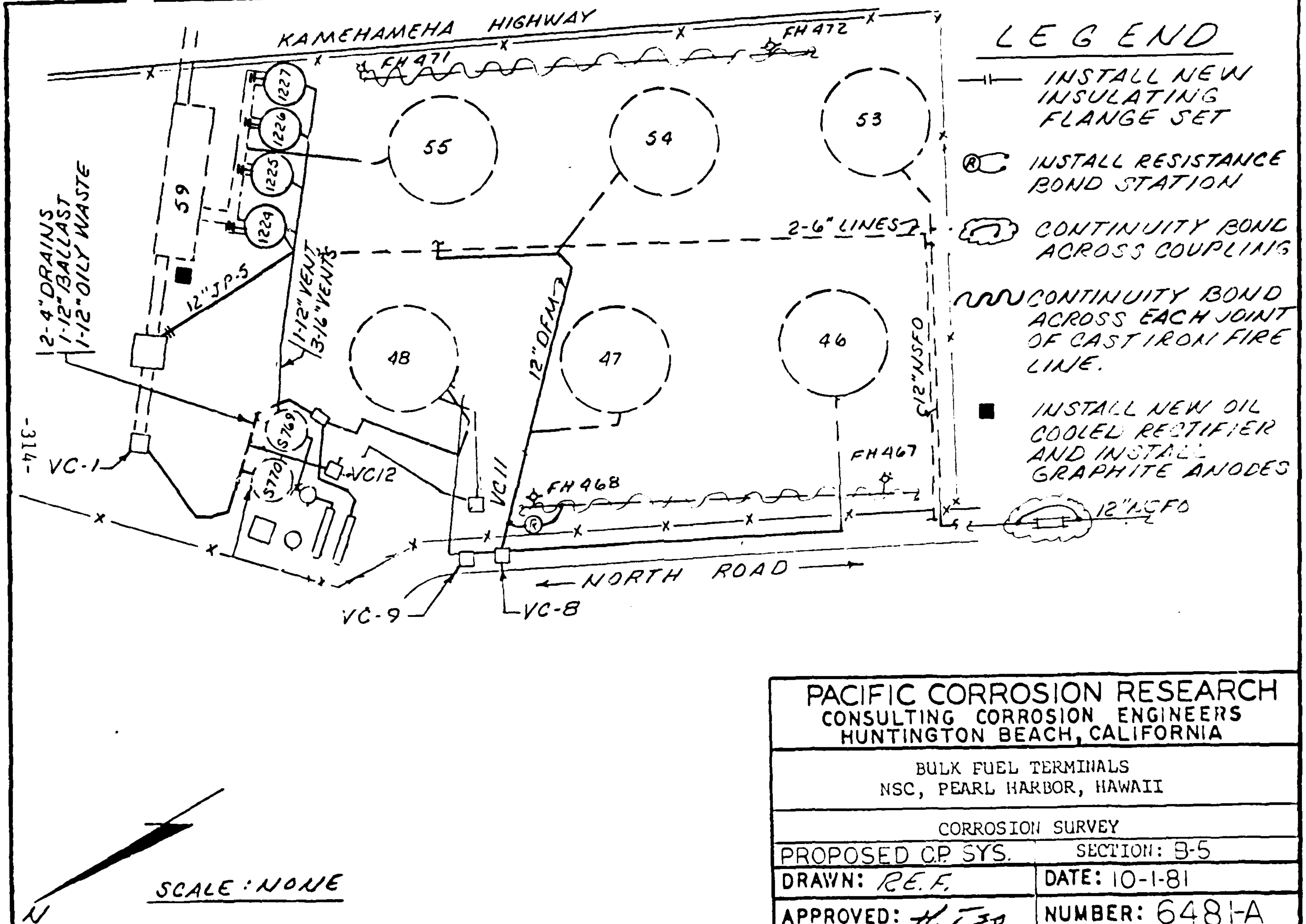
LEGEND

- •#1 SOIL RESISTIVITY LOCATION
- (1) PIPE TO SOIL POTENTIAL LOCATION
- - - - ABOVE GROUND POL LINES
- CT#1 CURRENT TEST LOCATION
- —— UNDERGROUND POL LINES

N

SCALE : NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: B-5
DRAWN: R.E.F.	DATE: 10-1-81
APPROVED: H.T.30	NUMBER: 6481



PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA

BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII

CORROSION SURVEY

PROPOSED C.P. SYS.	SECTION: B-5
DRAWN: R.E.F.	DATE: 10-1-81
APPROVED: H. Tso	NUMBER: 6481-A

SECTION B-6

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE LINES FROM VC-1 TO THE LOWER TANK FARM

SECTION B-6

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE LINES FROM VC-1 TO THE LOWER TANK FARM

SECTION B-6

SUMMARY

1. Conclusions:

Based on the field data obtained, the resulting conclusions are made:

A. The soil environment in Section B-6 can be classified as an area of moderate corrosion potential.

B. The POL lines of Section B-6 are not at a protective potential level. A majority of the potentials obtained are below -650 mv.

C. All magnesium anodes installed in the past were found to have deteriorated beyond their service life.

D. The results of current tests indicate that the protection for five casings at Bole Road Crossing will require 130 ma. Approximately 3,000 sq. ft. of coated steel POL lines of Section B-6 are to be considered for cathodic protection. This indicates that a protective current of 5 amperes D.C. will be required to provide a protective potential level.

E. The 4" gas main in the area southeast of Building 186 was found to be electrically continuous with the POL lines.

2. Recommendations:

A. Based on the field data obtained, it is indicated that a new anode bed consisting of a test box and two 32 lb. prepackaged magnesium anodes will be required to provide protection for the five casings at Bole Road Crossing.

B. For protection of the underground POL lines of Section B-6, it is recommended that two new anode beds be installed. Each of the two anode beds should consist of one test box, five 32 lb. magnesium anodes. The first anode bed should be installed south of Building 187 and the second anode bed should be installed west of the entrance gate at Hickam Air Force Base.

C. The above ground 8" NSFO line should be isolated from the underground line in Pumphouse 76, preventing possible short circuit between the POL lines and the reinforcing steel and/or other lines.

D. A bond should be made across the existing insulator, west of Building 42.

E. For partial protection of the underground POL lines of Section B-6, protection will be provided by the impressed current system as recommended in Section B-5, B-7, C-3 and C-4.

F. It is recommended that a resistance bond station be installed between the POL lines and the 4" gas line in the area adjacent to VC-23.

SECTION B-6

POL LINES INSIDE THE PEARL HARBOR COMPLEX INCLUDING THE LINES FROM VC-1 TO LOWER TANK FARM

1. Description.

A. Lines to be Protected:

(1) From VC-1 to VC-15

a. 12" NSFO Line - Coated Steel

(2) From VC-15 to VC-21

a. 18" NSFO Line - Coated Steel

(3) From VC-21 to Pumphouse 76

a. 8" NSFO Line - Coated Steel

B. Existing Cathodic Protection System:

The POL lines from VC-1 to VC-21 are partially protected by Rectifiers #8 and #9. The 8" POL line from VC-21 to Pumphouse 76 was to be protected by sacrificial anodes. During this survey, it was found that rectifiers #8 and #9 did not provide adequate protection for the POL lines of B-1 through B-5 as we mentioned in previous sections. The 8" NSFO line from VC-21 to Pumphouse 76 was to be protected by five 32 lb. magnesium anodes. These magnesium anodes were installed by directly connecting the anode leads to the above ground 8" NSFO lines by the base fuel personnel as "hot spot" protection. One magnesium anode was installed in each of the following locations:

(1) Northwest of Building 545

(2) South of southeast corner of Building 186

(3) Southeast of Building 227

(4) Approximately 60' east of entrance gate to Hickam Air Force Base

(5) East of VC-24

Anode open circuit potential of -1170 mv and an anode current output of 11 ma were obtained at the anode location east of VC-24. The results indicate these anodes have deteriorated and are beyond their useful service life. A primary magnesium anode should have an anode open circuit potential of more negative than -1600 mv.

2. Field Data and Evaluation of Data.

A. Soil Resistivity Measurements: A total of twenty sets of measurements were obtained at representative locations as shown in Table No. XI-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	23	Severe
Medium	2,000 - 10,000	45	Moderate
High	10,000 - 30,000	32	Slight unless other factors are pronounced
Very High	Above 30,000	0	Normally non-corrosive

The low resistivity indicates that a severe corrosion condition exists on all underground metallic structures. Twenty-three percent of the measurements were in the severe category and forty-five percent were in the medium or moderate category.

B. "As Found" Pipe-to-Soil Potentials: "As Found" potentials were obtained at each valve chamber and at representative locations where POL lines go underground. The results of these measurements indicate the the 8" NSFO lines of Section B-6 are not at a protective potential level. The results of these measurements are shown in Table No. XI-B.

C. Current Tests: Four current tests were conducted on the POL lines of Section B-6. Pipe-to-soil potentials were taken at the same locations as "as found" potentials with the test rectifier "off" and "on".

(1) Current Test No. 1 - This current test was conducted on the POL line in the lawn area near VC-21. Fourteen steel rods were installed southwest of VC-21, two posts and a short section of fence east of VC-21 were used as a temporary anode bed. The negative from the test rectifier was connected to the 8" NSFO line at VC-21. The current used for this test was 22 amperes D.C.. The results of this test are shown in Table No. XI-C.

(2) Current Test No. 2 - This test was conducted with the same anode configuration and the same negative connection as Current Test No. 1. The current was increased to 40 amperes D.C.. The results of this test are shown in Table No. XI-D.

(3) Current Test No. 3 - This test was conducted in the area near Pumphouse 76. Twelve fence posts, east of Pumphouse 76, were used as a temporary anode bed. The

negative was connected to the POL line in Pumphouse 76. The current used for thi test was 18 amperes D.C.. The results of this test are shown in Table No. XI-E.

(4) Current Test No. 4 - This current test was conducted as a continuity test. Pipe-to-soild potentials were obtained at each valve chamber of Section B-6 with existing Rectifier #9 turned "off" and "on". The results of this test are shown in Table No. IX-F, Section B-4.

(5) Current Test No. 5 - Current Test No. 5 was conducted on the five casings at Bole Road Crossing. One 12 volt dry battery was used for the D.C. power source. The negative from the battery was connected to each casing, one at a time. The current demand to provide protection for each casing was as follows:

Casing #1, abandoned	8 ma
Casing #2, abandoned	6.5 ma
Casing #3, 12" NSFO Line	72 ma
Casing #4, 12" DFM Line	30 ma
Casing #5, 16" DFM Line	9.7 ma

The results of Current Test No. 5 are shown in Table No. XI-F.

Based on the data obtained from these tests, the following results are concluded:

a. The POL lines from VC-1 to a coupling dresser, west of Building 42 are electrically continuous with the POL lines of Section B-1 thru B-9.

b. Rectifiers #8 and #9 do not provide adequate pro-

tection for the POL lines of this section.

c. The current requirement for the POL lines of Section B-6 will be moderate because most portions of the POL lines are above ground.

d. An insulator was found installed above ground on the 8" NSFO line, west of Building 42.

e. The POL lines are electrically continuous with the gas line in the area southeast of Building 186.

f. The five casings for the POL lines at Bole Road Crossing are not electrically continuous with the POL lines.

D. Inspection of Pipelines:

Approximately 75% of the POL lines of Section B-6 are installed above ground. The underground NSFO lines are coated steel. Visual inspection indicated the paint coating of the above ground NSFO lines is in good condition.

E. Leak History:

The leak history was discussed with Mr. John Kimi and Mr. Albert Wong of the Base Fuel Department. There were numerous leaks on the above ground POL lines and repaired in the past. The locations of these leaks are shown in PCR Drawing No. 6482.

3. Conclusions.

Based on the field data obtained, the resulting conclusions are made:

A. The results of soil resistivity measurements indicate that 23% of the readings are in the severe category and 45% are

in the medium or moderate category. The environment in Section B-6 can be classified as an area of moderate corrosion potential.

B. The POL lines of Section B-6 are not at a protective potential level. A majority of the potentials obtained are below -650 mv. It was found that POL lines west of Building 42 to Pumphouse 76 were not receiving any protection due to the installation of a coupling dresser in the POL line west of Building 42.

C. All magnesium anodes installed in the past were found to have deteriorated beyond their service life.

D. The results of current tests indicate that the protection for five casings at Bole Road Crossing will require 130 ma. A calculation of the underground POL lines of Section B-6 was made. Approximately 3,000 sq. ft. of coated steel POL lines are to be considered for cathodic protection. This indicates a protective current of 5 amperes D.C. will be needed to provide a protective potential level.

E. Rectifiers #8 and #9 do not provide adequate protective current for the POL lines of Section B-6.

F. The 4" gas main in the area southeast of Building 186 was found to be electrically continuous with the POL lines. We were advised by Mr. Art Lundberger of PWC, NSC, that the gas mains in the NSC area are owned by the Honolulu Gas Co. and maintained by the Honolulu Gas Co.. Most of the gas mains are cathodically protected.

G. Visual inspection indicated that the coating of the above ground POL lines of Section B-6 is in good condition.

4. Recommendations:

A. Based on the field data obtained, it is indicated that a new anode bed consisting of a test box and two 32 lb. prepackaged magnesium anodes will be required to provide protection for the five casings at Bole Road Crossing. It is recommended that two test leads be installed from each of these five casings and terminated in the test box.

B. For protection of the underground POL lines of Section B-6, it is recommended that two new anode beds be installed. Each of the two anode beds should consist of one test box, five 32 lb. magnesium anodes and an anode watering system. The first anode bed should be installed south of Building 187 and the second anode bed should be installed west of the entrance gate to Hickam Air Force Base.

C. The above ground 8" NSFO line should be isolated from the underground line in Pumphouse 76, preventing possible short circuiting between the POL linesand the reinforcing steel and/or other lines.

D. A bond should be made across the existing insulator west of Building 42.

E. For partial protection of the underground POL lines of Section B-6, protection will be provided by the impressed current system as recommended in Section B-5, B-7, C-3 and C-4.

F. It is recommended that a resistance bond station be installed between the POL lined and the 4" gas line in the area adjacent to VC-23.

NOTE: The locations of the pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No.'s 6482 and 6483.

The recommended C.P. systems for Section B-6 are shown on PCR Drawings No. 6482-A and 6483-A.

NAVFAC 11013/7 (1 78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 1 OF 1

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION B-6

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ______

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
32 LB. PREPACKAGED MAGNESIUM ANODES	12	ea	120.00	1440.00	150.00	1800.00	270.00	3240.00
CONCRETE TEST BOX/CAST IRON LIDS	3	ea	45.00	135.00	75.00	225.00	120.00	360.00
#8 HMP STRANDED COPPER CABLE	150	ft	0.75	112.50	0.15	22.50	0.90	135.00
1" PVC CLASS 200, PLASTIC PIPE	150	ft	0.75	112.50	0.38	57.00	1.13	169.50
TERRA TAPE	150	ft	0.23	34.50	0.08	12.00	0.31	46.50
SPLIT BOLTS	7	ea	1.05	7.35	4.50	31.50	5.55	38.85
HOSE CONNECTION ADAPTER	3	ea	7.50	22.50	7.50	22.50	15.00	45.00
0.01 OHM SHUNT	3	ea	7.50	22.50	7.50	22.50	15.00	45.00
BRASS TAGS	14	ea	1.50	21.00	1.50	21.00	3.00	42.00
INSULATORS	1	ea	45.00	45.00	75.00	75.00	120.00	120.00
TRENCH	120	ft	-	-	4.50	540.00	4.50	540.00
SUBTOTAL				1952.85		2829.00		4781.85
10% MIS. MATERIAL & LABOR				195.28		282.90		478.18
SUBTOTAL				2148.13		3111.90		5260.03
30% CONSTRUCTION PROFIT				644.43		933.57		1578.00
TOTAL				2792.56		4045.47		6838.03

S/N 0105-LF-010-1335
* G P O : 1979-689-016/4302

SECTION B-6

SOIL RESISTIVITIES

TABLE NO. XI-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	East of VC-1	10000	360	200
2.	East of Bldg. 795	3100	2000	800
3.	West of Bldg. 235	2800	4000	1700
4.	North of VC-9	2800	1100	1020
5.	North of Bldg. 60	14000	5100	1160
6.	North side of Bole St., east of North Rd.	5000	2000	680
7.	West of VC-14	7500	5900	3000
8.	North of Bldg. 553	14500	13000	5000
9.	NE of Rectifier #9	19000	19000	6000
10.	West of VC-18	60000	35000	4000
11.	West of Tank 34	55000	20000	7600
12.	VC-21	19000	13000	3000
13.	South of VC-22	13500	5000	2000
14.	West of Bldg. 93	12500	3800	1780
15.	North of VC-23	18500	5000	3600
16.	South Ave. & Ave. "D"	4000	1400	1120
17.	East of Hickam Gate	8500	8800	7400
18.	East of VC-24	3400	3800	4000
19.	North of Tank 13	10000	7100	8000
20.	North of Tank 10	15500	20000	13600

SECTION B-6

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. XI-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	VC-1	
	6" Multi.	
	HIRI side of Ins.	-840
	Navy side of Ins.	-640
	16" DFM from Pumphouse 59	-640
	18" JP-5 from Pumphouse 59	-640
	18" DFM from Pumphouse 59	-640
	18" DFM from Pumphouse 59	-640
	12" NSFO to VC-7	-640
	6" JP-5 to loading rack	-640
	4" Drain to VC-12	-620
	12" NSFO to Merry Pt.	-640
	18" DFM to Merry Pt.	-640
	4" Drain and 12" Ballast are fiberglass.	
2.	Hose bibb south side	-500
3.	VC-10	
	32" Avgas to VC-1	-640
	32" Avgas to "V" Docks	-640
	10" Mogas to VC-1	-640
	10" Mogas to south	-640
4.	VC-9	
	10" NSFO to VC-8	-680

	12" NSFO to VC-8	-680
	16" DFM to VC-8	-680
5.	VC-8	
	10" NSFO	-680
	12" NSFO	-680
	16" DFM	-680
6.	Bole Street Crossing	
	12" NSFO to Upper Tank Farm	-190
	12" NSFO to VC-8	-665
	16" DFM to VC-8	-665
7.	VC-14	
	12" NSFO to VC-15	-620
	12" DFM to VC-32	-620
	12" DFM to VC-32	-620
8.	VC-15	
	12" NSFO to VC-14	-655
	18" NSFO (abandoned)	-655
	18" NSFO to VC-18	-655
9.	VC-18	
	10" Line to Middle Tank Farm	-630
	18" NSFO to VC-21	-630
	8" DFM to North	-630
	6" line (abandoned)	-460
	6" line (abandoned)	-560
	8" DFM to West (abandoned)	-470
	2 - 10" line in Middle Tank Farm	-630
10.	VC-21	
	12" NSFO to VC-20	-670

	18" NSFO to VC-18	-670
	18" NSFO to VC-22	-670
11.	VC-22	
	8" NSFO	-680
13.	Railroad Crossing at "D" Street	
	8" NSFO North Side	-620
	South Side	-565
14.	Dresser Coupling in 8" NSFO, SE of Bldg. 219	
	East side of coupling	-620
	West side of coupling	-465
15.	Crossing at Hickam AFB Gate	
	8" NSFO, east side	-470
	8" NSFO, west side	-460
	Casing, east side	-450
	Casing, west side	-450
16.	VC-24	
	8" NSFO	-480
17.	Building 76, Pump Station	
	8" NSFO to east	-420
	8" NSFO to east	-420
	8" NSFO to south	-420
	8" NSFO to south	-420
	8" NSFO to west	-420
	8" NSFO to north	-420
	8" NSFO to north	-420
18.	Tank 10	
	18" NSFO	-490
19.	Tank 11	

	18" NSFO	-475
20.	Tank 13	
	18" NSFO	-490
21.	Tank 17	
	18" NSFO	-510
22.	Tank 17	
	6" Fire Foam Line	-470

SECTION B-6

CURRENT TEST NO. 1

TABLE NO. XI-C

Location: VC-21.

Anodes used for current test: Fourteen steel rods, two posts and short section of fence as a temporary anode bed.

Negative Connection: 8" NSFO at VC-21.

Rectifier D.C. Output: 37 volts - 22 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC-1			
	6" Multi			
	HIRI side of Ins.	-840	-830	-10*
	Navy side of Ins.	-640	-650	10
	16" DFM from Pumphouse 59	-640	-650	10
	18" JP-5 from Pumphouse 59	-640	-650	10
	18" DFM from Pumphouse 59	-640	-650	10
	18" DFM to VC-7	-640	-650	10
	12" NSFO to VC-7	-640	-650	10
	6" JP-5 to loading rack	-640	-650	10
	4" Drain to VC-12	-640	-650	10
	12" NSFO to Merry Pt.	-640	-650	10
	18" DFM to Merry Pt.	-640	-650	10
2.	Hose bibb, south side of VC-1	-500	-505	5
3.	VC-9			
	10" NSFO to VC-8	-665	-680	15
	12" NSFO to VC-8	-665	-680	15
	16" DFM to VC-8	-665	-680	15

4.	VC-8			
	10" NSFO	-665	-680	15
	12" NSFO	-665	-680	15
	16" DFM	-665	-680	15
5.	Bole Street Crossing			
	12" NSFO to Upper Tank Farm	-190	-185	-5*
	12" NSFO to VC-8	-665	-705	40
	16" DFM to VC-8	-665	-705	40
6.	Unknown 22" steel line SW of Bldg. 1273	-440	-440	0
7.	Dresser Coupling in 12" NSFO line, east of Bldg. 584			
	Middle Tank Farm side	-210	-205	-5*
	VC-14 side	-720	-765	40
8.	VC-14			
	12" NSFO to VC-15	-590	-635	45
	12" DFM to VC-32	-590	-635	45
	12" DFM to VC-32	-590	-635	45
	6" (abandoned)	-335	-365	30
	6" (abandoned)	-335	-365	30
9.	VC-15			
	12" NSFO to VC-14	-655	-690	35
	18" NSFO (abandoned)	-655	-690	35
	18" NSFO to VC-18	-655	-690	35
10.	VC-18			
	10" line in Middle Tank Farm	-630	-680	50
	18" NSFO to VC-21	-630	-680	50
	8" DFM to North	-630	-680	50
	6" Line (abandoned)	-460	-450	-10*

	8" DFM to west (abandoned)	-560	-580	20
	2-10" lines to Middle Tank Farm	-630	-680	50
11.	VC-21			
	12" NSFO to VC-20	-670	-920	250
	18" NSFO to VC-18	-670	-920	250
	8" NSFO to VC-22	-670	-920	250
12.	VC-22			
	8" NSFO	-680	-780	100
13.	VC-23			
	8" NSFO	-645	-745	100
14.	Railroad Crossing at "B" St.	-565	-700	135
15.	Dresser Coupling in 8" NSFO			
	Lower Tank Farm side	-465	-465	0
	N.S.C. side	-620	-655	35
16.	VC-20			
	10" C.I. Water	-540	-540	0
	12" DFM	-710	-840	130

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION B-6

CURRENT TEST NO. 2

TABLE NO. XI-D

Location: VC-21.

Anodes used for current test: Fourteen steel rods, two posts and. two sections of fence as a temporary anode bed.

Negative Connection: 8" NSFO at VC-21.

Rectifier D.C. Output: 51 volts - 40 amperes D,C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	VC-1			
	6" Multi			
	HIRI side of Ins.	-840	-825	-15*
	Navy side of Ins.	-640	-665	25
	16" DFM from Pumphouse 59	-640	-665	25
	18" JP-5 from Pumphouse 59	-640	-665	25
	18" DFM from Pumphouse 59	-640	-665	25
	18" DFM to VC-7	-640	-665	25
	12" NSFO to VC-7	-640	-665	25
	6" JP-5 to loading rack	-640	-665	25
	4" Drain to VC-12	-640	-665	25
	12" NSFO to Merry Pt.	-640	-665	25
	18" DFM to Merry Pt.	-640	-665	25
2.	Hose bibb south side of VC-1	-500	-510	10
3.	VC-9			
	10" NSFO to VC-8	-665	-700	35
	12" NSFO to VC-8	-665	-700	35

	16" DFM to VC-8	-665	-700	35
4.	VC-8			
	10" NSFO	-665	-700	35
	12" NSFO	-665	-700	35
	16" DFM	-665	-700	35
5.	Bole Street Crossing			
	12" NSFO to Upper Tank Farm	-190	-180	-10*
	12" NSFO to VC-8	-665	-735	70
	16" DFM to VC-8	-665	-735	70
6.	Unknown 22" steel line SW of Bldg. 1273	-440	-440	0
7.	Dresser Coupling in 12" NSFO line east of Bldg. 584			
	Middle Tank Farm side	-210	-200	-10*
	VC-14 side	-720	-800	80
8.	VC-14			
	12" NSFO to VC-15	-590	-675	85
	12" DFM to VC-32	-590	-675	85
	12" DFM to VC-32	-590	-675	85
	6" (abandoned)	-335	-400	65
	6" (abandoned)	-335	-400	65
9.	VC-15			
	12" NSFO to VC-14	-655	-735	80
	18" NSFO (abandoned)	-655	-735	80
	18" NSFO to VC-18	-655	-735	80
10.	VC-18			
	10" line to Middle Tank Farm	-630	-730	100
	18" NSFO to VC021	-630	-730	100

	8" DFM to North	-630	-730	100
	6" Line (abandoned)	-460	-445	-15*
	8" DFM to West (abandoned)	-470	-425	-45*
	6" line (abandoned)	-560	-590	30
	2-10" line to Middle Tank Farm	-630	-710	80
11.	VC-21			
	12" NSFO to VC-20	-670	-1070	400
	18" NSFO to VC-18	-670	-1070	400
	8" NSFO to VC-22	-670	-1070	400
12.	VC-22			
	8" NSFO	-680	-870	190
13.	VC-23			
	8" NSFO	-645	-855	210
14.	Railroad Crossing at "B" St.	-565	-760	195
15.	Dresser Coupling in 8" NSFO			
	Lower Tank Farm side	-465	-460	-5*
	N.S.C. side	-620	-685	65
16.	VC-20			
	10" C.I. Water	-540	-535	-5*
	12" DFM	-710	-920	210

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION B-6

CURRENT TEST NO. 3

TABLE NO. XI-E

Location:	Pump Station at Bldg. 76.
Anodes used for current test:	Twelve steel fence posts used as a temporary anode bed.
Negative Connection:	8" NSFO in Bldg. 76.
Rectifier D.C. Output:	37 volts - 18 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Fire Hydrant line, east of Tank #17	-440	-445	5
2.	12" NSFO, Tank 17	-475	-545	70
3.	12" NSFO, Tank 13	-490	-565	75
4.	12" NSFO, Tank 11	-475	-570	95
5.	12" NSFO, Tank 10	-490	-575	85
6.	Pumphouse 76	-490	-730	240
7.	F.H. west of VC-24	-490	-540	60
8.	VC-24	-515	-720	225
9.	Foam Hydrant, South of Tank 10	-490	-715	225
10.	Fire Hydrant 356	-490	-475	-15*
11.	8" NSFO near Hickam AFB gate	-505	-840	335
12.	8" NSFO casing near Hickam AFB Gate	-505	-575	70
13.	Dresser Coupling in 8" NSFO SE of Bldg. 212			
	Lower Tank Farm side	-480	-720	240
	N.S.C. side	-635	-640	5

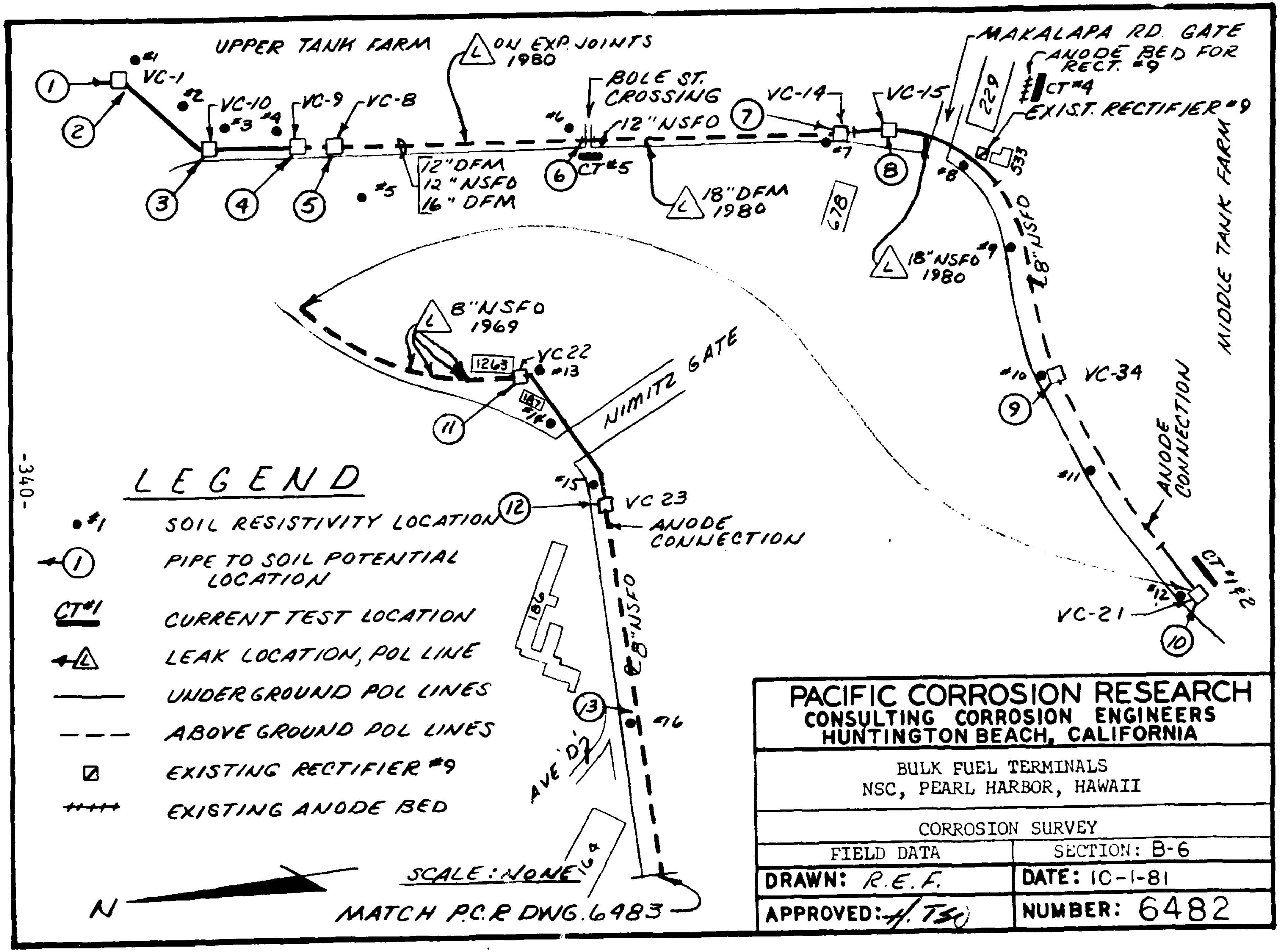
SECTION B-6

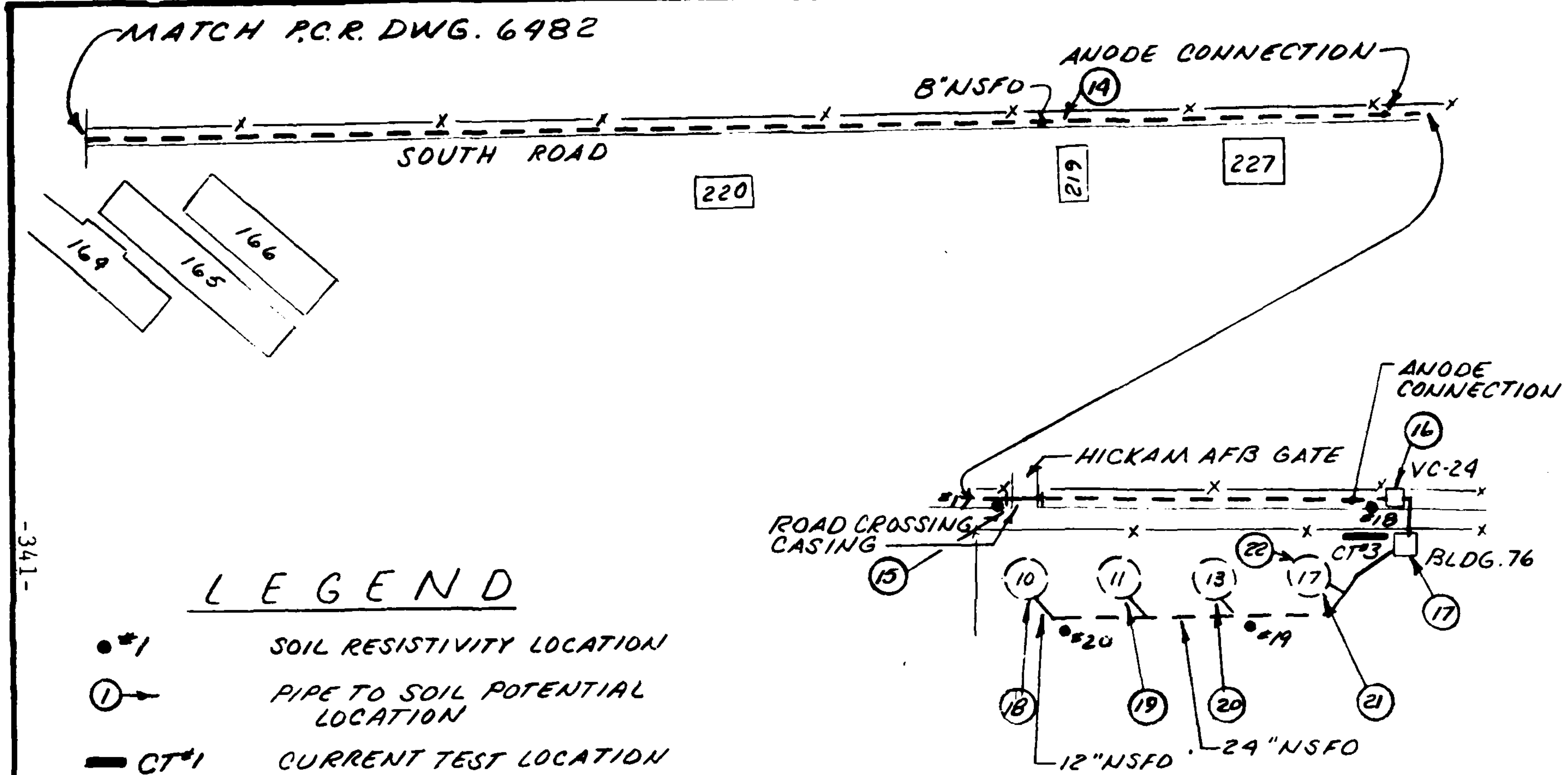
CURRENT TEST NO. 5 CASINGS AT BOLE STREET CROSSING

TABLE NO. XI-F

Location:	Bole Street and North Road, northwest of Bldg. 1262.
Anodes used for current test:	One steel rod was used as a temporary anode.
Negative Connection:	To each casing one at a time.

Rdg. No.	Location	D.C. Current I(ma)	Pipe to Soil Potentials (mv) I(Off)	I(On)	Change
1.	Casing #1 (abandoned)	8	-420	-920	500
2.	Casing #2 (abandoned)	6.5	-465	-890	425
3.	Casing #3, 12" NSFO	97	-280	-940	660
4.	Casing #4, 12" NSFO	30	-290	-890	600
5.	Casing #5, 16" DFM	7.2	-315	-1090	775


UPPER TANK FARM
VC-1
VC-10
VC-9
VC-8
ON EXP. JOINTS 1980
12" DFM
12" NSFO
16" DFM
BOLE ST. CROSSING
12" NSFO
CT#5
18" DFM 1980
VC-14
VC-15
678
MAKALAPA RD. GATE
ANODE BED FOR RECT. #9
CT#4
EXIST. RECTIFIER #9
229
533
18" NSFO 1980
8" NSFO
MIDDLE TANK FARM
VC-34
ANODE CONNECTION
CT#1&2
VC-21
8" NSFO 1969
1263
VC22
NIMITZ GATE
VC 23
ANODE CONNECTION
8" NSFO
186
AVE 'D'
164
LEGEND
SOIL RESISTIVITY LOCATION
PIPE TO SOIL POTENTIAL LOCATION
CURRENT TEST LOCATION
LEAK LOCATION, POL LINE
UNDERGROUND POL LINES
ABOVE GROUND POL LINES
EXISTING RECTIFIER #9
EXISTING ANODE BED
SCALE: NONE
N
MATCH P.C.R DWG. 6483
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA
BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII
CORROSION SURVEY
FIELD DATA
SECTION: B-6
DRAWN: R.E.F.
DATE: 10-1-81
APPROVED: H. TSU
NUMBER: 6482



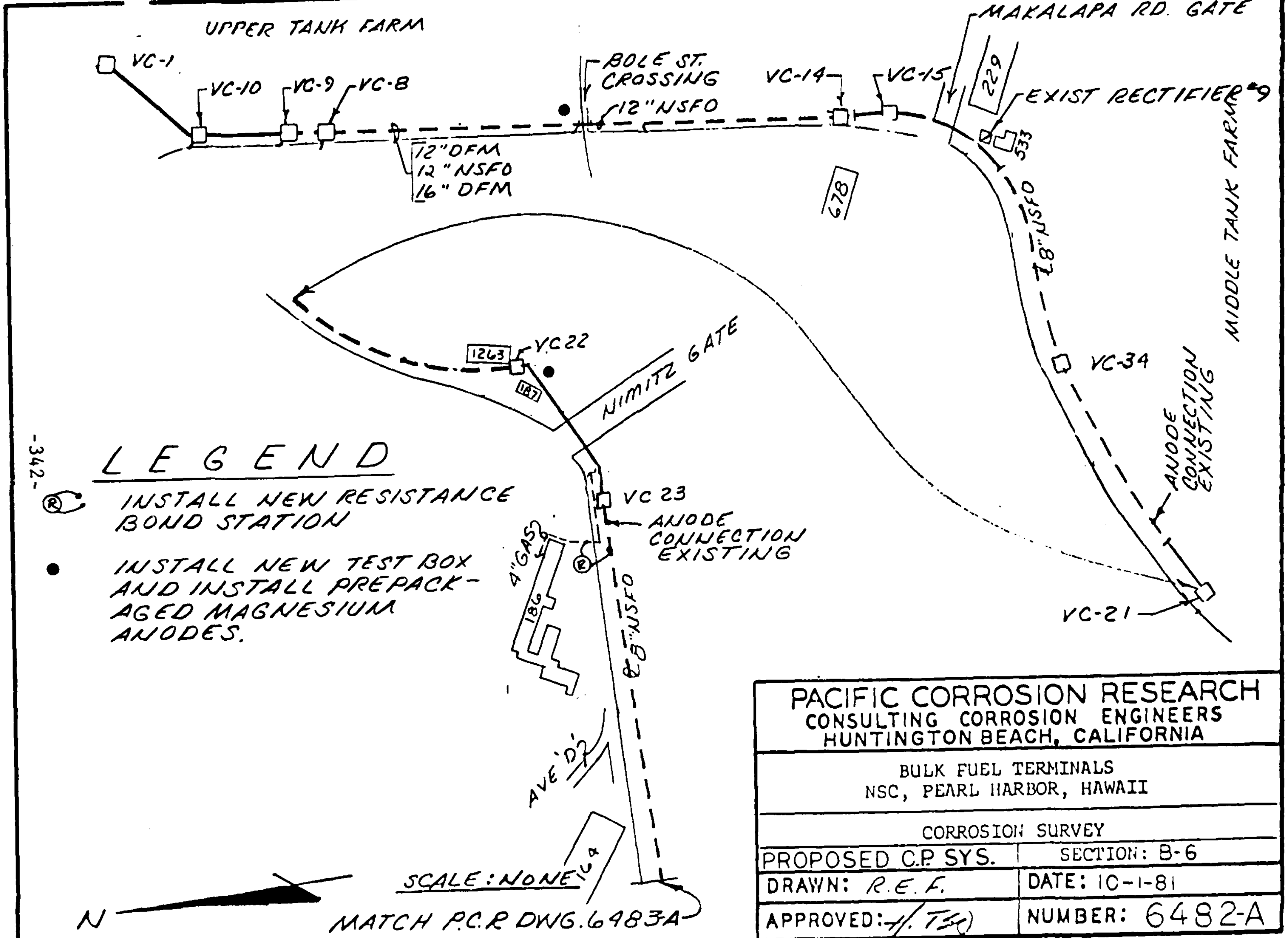
LEGEND

- ●#1 SOIL RESISTIVITY LOCATION
- ①→ PIPE TO SOIL POTENTIAL LOCATION
- ▬ CT#1 CURRENT TEST LOCATION
- ——— UNDERGROUND POL LINE
- - - - ABOVE GROUND POL LINE
- △→ LEAK LOCATION, POL LINE

SCALE: NONE

N

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: B-6
DRAWN: R.E.F.	DATE: 10-1-81
APPROVED: H.T.S.	NUMBER: 6483

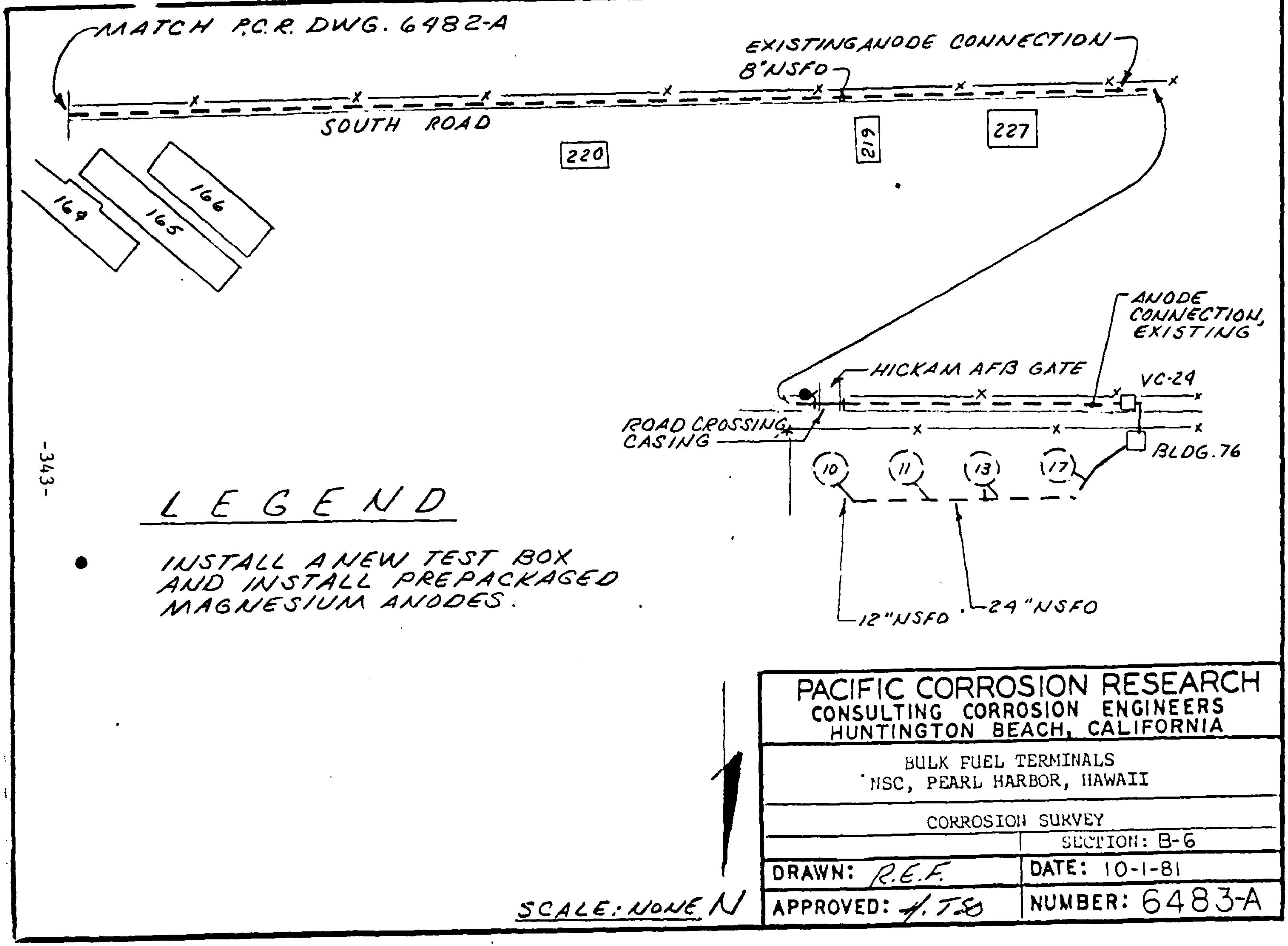


PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA

BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII

CORROSION SURVEY

PROPOSED C.P. SYS.	SECTION: B-6
DRAWN: R.E.F.	DATE: 10-1-81
APPROVED:	NUMBER: 6482-A


MATCH P.C.R. DWG. 6482-A
EXISTING ANODE CONNECTION
8"NSFO
SOUTH ROAD
220
219
227
166
165
164
ANODE CONNECTION, EXISTING
HICKAM AFB GATE
VC-24
ROAD CROSSING CASING
BLDG. 76
10
11
13
17
12"NSFO
24"NSFO
LEGEND
INSTALL A NEW TEST BOX AND INSTALL PREPACKAGED MAGNESIUM ANODES.
SCALE: NONE
N
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA
BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII
CORROSION SURVEY
SECTION: B-6
DRAWN: R.E.F.
DATE: 10-1-81
APPROVED: H.T.S.
NUMBER: 6483-A

SECTION B-7

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE LINES FROM THE MIDDLE TANK FARM TO MIKE DOCKS

SECTION B-7

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE LINES FROM THE MIDDLE TANK FARM TO MIKE DOCKS

SECTION B-7

SUMMARY

1. Conclusions:

Based on the field data obtained, the following results were observed:

A. The soil environment in Section B-7 can be classified as an area of moderate corrosion potential.

B. The POL lines of Section B-7 are not at a protective potential level with all potentials below -750 mv.

C. The POL Lines are electrically continuous to each other from VC-34 to the Middle Tank Farm. This section of POL lines were also found found to be electrically continuous with the POL lines of Sections B-1 thru B-9.

D. The cast iron fire mains around the Middle Tank Farm are not electrically continuous with the POL lines of Section B-7.

E. Existing Rectifier #9 does not provide adequate protective current for the POL lines of Section B-7 and the tanks of Section C-3.

F. Approximately 8,000 sq. ft. of coated steel lines are to be considered for cathodic protection. Approximately 15 amperes D.C. will be required to provide a protective potential for these lines.

2. Recommendations:

A. It is recommended that a new anode bed will be required to provide protective current for the POL lines of Section B-7 and portions of tanks of Section C-3. This anode bed will consist of one new oil cooled rectifier, ten (10) 4"x40" graphite anodes and an anode watering system. The anodes should be installed in the southern area of the Middle Tank Farm.

B. It is recommended that the cast iron fire mains around the Middle Tank Farm be bonded across each joint with a No. 8 TW stranded copper cable. A resistance bond station should be installed between the POL lines and and the cast iron fire main near Fire Hydrant #461.

C. The POL lines to the tanks should be isolated with insulating flanges in Pumphouse #31.

SECTION B-7

POL LINES INSIDE THE PEARL HARBOR COMPLEX INCLUDING THE LINES FROM THE MIDDLE TANK FARM TO MIKE DOCKS

1. Description.

A. Lines to be Protected:

(1) From Tank #34 to North of Tank #35

a. 8" DFM line - Coated Steel

(2) From Tank #35 to VC-34

a. 8" DFM line - Coated Steel

b. 10" Drain line - Coated Steel

(3) From Tank #36 to Pumphouse #31

a. 8" DFM line - Coated Steel

(4) From Tank #37 to Pumphouse #31

a. 8" DFM line - Coated Steel

(5) From Tank #38 to Pumphouse #31

a. 12" DFM line - Coated Steel

(6) From VC-34 to VC-29

a. 6" DFM line - Coated Steel

(7) From Pumphouse to VC-29

a. 12" DFM line - Coated Steel

B. Existing Cathodic Protection System:

This section of POL lines and the tanks of Section C-3 were originally designed to be protected by an impressed current cathodic protection system. The existing anode bed for existing Rectifier #9 was abandoned due to cable leaks. A new anode bed which consists of nine 3"x60" graphite anodes was installed in a new location, south of Building 229 by base fuel personnel in 1979. The existing rectifier was

replaced with a new air cooled rectifier located on the west side of Building 553.

Rectifier #9 - (New)

(i) Rectifier Location:	Rectifer #9 is located on the west side of Building 553.
(ii) Rectifier Unit:	Mfg. - Goodall Serial No. - 79C1380 D.C. Capacity - 40 V, 80 A Operating at - Tap setting 4-5 D.C. Output - 50V, 9 A Date Recorded - Aug. 4, 1981
(iii) Anode Bed Location:	Nine 3"x60" graphite anodes installed south of Building 229 in 1979.

2. Field Work and Evaluation of Data.

A. Soil Resistivity Measurements: A total of twelve sets of measurements were obtained at representative locations as shown in Table No. XII-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	8	Severe
Medium	2,000 - 10,000	92	Moderate
High	10,000 - 30,000	0	Slight unless other factors are pronounced
Very High	Above 30,000	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on underground metallic structures. Eight percent of the measurements obtained were in the severe category and ninty-two percent were in the medium or moderate category.

B. "As Found" Pipe-to-Soil Potentials: "As Found" pipe-to-soil potentials were obtained at each valve chamber, each tank and at the point where pipelines enter underground. The results of these measurements indicate that the POL lines of Section B-7 are not at a protective potential level with all readings below -700 mv. The results of these measurements are shown in Table No. XII-B.

C. Current Tests: Three current tests were conducted on the POL lines of Section B-7. Pipe-to-soil potentials were obtained at representative locations throughout Section B-7. During these tests, potentials were obtained with each test rectifier turned "off" and "on".

(1) Current Test No. 1 - This current test was conducted in the area southwest of Tank #36. Twelve steel rods were installed northeast of Building 1557 as a temporary anode bed. The negative wire from a test rectifier was connected to the negative cable at existing Rectifier #9. The current used for this test was 15 amperes D.C.. The results of this test are shown in Table No. XII-C.

(2) Current Test No. 2 - This current test was conducted with the same anode bed configuration and negative connection as Current Test No. 1. The current was increased to 25 amperes D.C.. The results of this test

are shown in Table No. XII-D.

(3) Current Test No. 3 - This current test was conducted as a continuity test. Pipe-to-soil potentials were obtained at various valve chambers in Sections B-4, B-5, B-6, B-7 and B-9 with existing Rectifier #9 turned "off" and "on". The results of this trest are shown in Table No. IX-F of Section A-4.

Based on the data obtained from these tests, the following results are concluded

a. POL lines of Section B-7 are electrically continuous with the POL lines of Section B-1 thru B-9 and the tanks of Section C-3.

b. Existing Rectifier #9 does not provide adequate protection for the POL lines of Section B-7 and the tanks of Section C-3.

c. The current demand for the protection of the POL lines of Section B-7 will be moderate.

d. The cast iron fire main around the Middle Tank Farm is not electrically continuous with the POL lines of Section B-7 and the tanks of Section C-3.

e. The 4" foam lines to the tanks were found to be disconnected at each tank. They are electrically discontinuous with the POL lines and tanks.

D. Inspection of Pipelines: The underground POL lines of Section B-7 are coated steel. The above ground POL lines are covered with a light green paint. The coating appears to be in good condition.

E. Leak History: We were advised by the base fuel personnel that no leaks were found in the past.

3. Conclusions.

Based on the field data obtained, the following results were observed:

A. Soil resistivity measurements indicate that 92% of the readings are in the moderate category. The environment in Section B-7 can be classified as an area of moderate corrosion potential.

B. The POL lines of Section B-7 are not at a protective potential with all potentials below -750 mv.

C. The POL lines are electrically continuous to each other from VC-34 to the Middle Tank Farm. This section of POL lines also were found to be electrically continuous with the POL lines of Sections B-1 thru B-9.

D. The cast iron fire mains around the Middle Tank Farm are not electrically continuous with the POL lines of Section B-7.

E. Existing Rectifier #9 does not provide adequate protective current for the POL lines of Section B-7 and the tanks of Section C-3.

F. The results of current tests conducted indicate that current demand for this section of POL lines will be moderate. Approximately 8,000 sq. ft. of coated steel lines are to be considered for cathodic protection. Approximately 15 amperes D.C. will be required to provide a protective potential for these lines.

G. Inspection of POL lines above ground indicated that the coating of these lines is in good condition.

4. Recommendations.

A. It is recommended that a new anode bed will be required to provide protective current for the POL lines of Section B-7 and portions of tanks of Section C-3. This anode bed will consist of one oil cooled rectifier, ten 4"x40" graphite anodes and an anode watering system. The anodes should be installed in the southern area of the Middle Tank Farm.

B. It is recommended that the cast iron fire mains around the Middle Tank Farm be bonded across each joint with a No. 8 TW stranded copper cable. A resistance bond station should be installed between the POL lines and the cast iron fire main near Fire Hydrant #461.

C. The POL lines to the tanks should be isolated with insulating flanges in Pumphouse #31.

NOTE: The locations of the pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No. 6501.

The recommended C.P. system of Section B-7 is shown on PCR Drawing No. 6501-A.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982
SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM CORROSION SURVEY, SECTION B-7

STATUS OF DESIGN: PED ☐ 30% ☒ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
OIL COOLED RECTIFIER	1	ea	1950.00	1950.00	600.00	600.00	2550.00	2550.00
4"x40" GRAPHITE ANODES	10	ea	210.00	2100.00	150.00	1500.00	360.00	3600.00
COAL COKE BREEZE	3000	lb	0.30	900.00	0.08	240.00	0.38	1140.00
CONCRETE PAD	1	ea	150.00	150.00	600.00	600.00	750.00	750.00
1" PVC CLASS 200, PLASTIC PIPE	600	ft	0.75	450.00	0.15	90.00	0.90	540.00
#2 HMP STRANDED COPPER CABLE	400	ft	1.50	600.00	0.15	60.00	1.65	660.00
INSULATOR FLANGES	10	ea	45.00	450.00	75.00	750.00	120.00	1200.00
RESISTANCE BOND STATION	1	ea	150.00	150.00	150.00	150.00	300.00	300.00
HOSE CONNECTION ADAPTER	1	ea	7.50	7.50	7.50	7.50	15.00	15.00
SPLIT BOLTS	15	ea	1.05	15.25	4.50	67.50	5.55	83.25
COAL TAR ENAMEL (1 GALLON CAN)	1	ea	22.50	22.50	45.00	45.00	67.50	67.50
BUTYL TAPE	2	rl	37.50	75.00	45.00	90.00	82.50	165.00
RUBBER TAPE	6	rl	4.50	27.00	7.50	45.00	12.00	72.00
PLASTIC TAPE	6	rl	4.50	27.00	7.50	45.00	12.00	72.00
TERRA TAPE	350	ft	0.23	80.50	0.08	28.00	0.31	108.50
TRENCH	350	ft	-	-	4.50	1575.00	4.50	1575.00
SUBTOTAL				7005.75		5893.00		12898.25

S/N 0105-LF-010-1335
★ G.P.O.: 1979-689-016/4302

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 2 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM CORROSION SURVEY, SECTION B-7

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
10% MISC. MATERIALS & LABOR				700.00		580.00		1289.00
SUBTOTAL				7705.25		6482.00		14188.25
30% CONSTRUCTION PROFIT				2311.57		1944.60		4256.17
TOTAL				10016.82		8426.60		18443.42

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

SECTION B-7

SOIL RESISTIVITIES

TABLE NO. XII-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	W side of Tank 35	2500	2500	2600
2.	Between Tanks 35 & 35	3550	4000	4000
3.	NW side of Tank 34	3950	4900	5200
4.	S side of Tank 34	3400	3400	3400
5.	N side of Tank 35	3800	2700	2800
6.	S side of Tank 38	6000	3200	3200
7.	NE of Tank 37	3350	2600	3000
8.	E of Tank 36	3550	2200	2000
9.	S of Tank 36	1500	1300	980
10.	Pumphouse 31	3900	3000	4200
11.	200' SW of Tank 38	3800	2800	3600
12.	200' W of Pumphouse 31	4200	4200	4000

SECTION B-7

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. XII-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	8" DFM Line at Tank 34 (S746)	-580
2.	10" DFM Line at Tank 35 (S747)	-560
3.	VC-34, Bldg. 162	
	18" NSFO Line	-640
	10" DFM Line from Tank 34 & 35	-640
4.	VC-29	
	12" DFM Line	-650
5.	VC-31	
	10" DFM Line	-620
6.	VC-32	
	10" DFM Line	-740
7.	F.H. #453, E. of Tank 35 (S747)	-375
8.	8" DFM Line at Tank 36	-595
9.	Pumphouse 31	
	8" DFM Line to Tanks 31 & 37	-650
	12" DFM Line to Tank 38	-475
	12" DFM Line to VC-34	-450
10.	8" DFM Line at Tank 37 (S749)	-600
11.	F.H. #461, E. of Pumphouse 31	-620
12.	12" DFM Line at Tank 38 (S750)	-670
13.	F.H. #462, SW. of Tank 38	-480

SECTION B-7

CURRENT TEST NO. 1

TABLE NO. VII-C

Location:	SW. of Tank #36.
Anodes used for current test:	New anode bed consisting of 12 steel rods installed SW. of Tank #36.
Negative Connection:	To existing negative.
Rectifier D.C. Output:	15 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	At tank 34 (S746) 8" DFM Line	-560	-590	30
2.	At tank 35 (S747) 10" DFM Line	-575	-610	35
3.	Bldg. 162, VC-34			
	18" NSFO Line	-670	-710	40
	10" DFM line from Tanks 34 & 35	-660	-700	40
4.	VC-29, 12" DFM line	-690	-730	40
5.	VC-31, 10" DFM line	-700	-750	50
6.	VC-32, 10" DFM line	-740	-780	40
7.	F.H. #453, E. of Tank 35 (S747)	-400	-400	0
8.	At tank 36 (S748), 8" DFM Line	-620	-660	40
9.	Pumphouse 31			
	8" DFM line to Tank 36 & 37	-450	-500	50
	12" DFM line to Tank 38	-510	-560	50
	12" DFM line to VC-34	-450	-500	50
10.	At Tank 37 (S749), 8" DFM Line	-600	-630	30

11.	F.H. #46, E. of Pumphouse 31	-600	-590	-10*
12.	At Tank 38 (S750) 12" DFM Line	-660	-680	20
13.	F.H. #462, SW. of Tank 38	-490	-480	-10*

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of the test current.

SECTION B-7

CURRENT TEST NO. 2

TABLE NO. VII-D

Location:	SW. of Tank #36.
Anodes used for current test:	New anode bed consisting of 12 steel rods installed SW. of Tank #36.
Negative Connection:	To existing negative.
Rectifier D.C. Output:	25 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	At tank 34 (S746) 8" DFM Line	-565	-620	55
2.	At tank 35 (S747) 10" DFM Line	-580	-640	60
3.	Bldg. 162, VC-34			
	18" NSFO Line	-680	-780	100
	10" DFM line from Tanks 34 & 35	-680	-770	90
4.	VC-29, 12" DFM Line	-700	-790	90
5.	VC-31, 10" DFM Line	-705	-810	105
6.	VC-32, 10" DFM Line	-745	-850	105
7.	F.H. #453, E. of Tank 35 (S747)	-400	-400	0
8.	At tank 36 (S748), 8" DFM Line	-625	-730	105
9.	Pumphouse 31			
	8" DFM line to Tank 36 & 37	-450	-600	150
	12" DFM line to Tank 38	-520	-630	110
	12" DFM line to VC-34	-450	-600	150
10.	At Tank 37 (S749), 8" DFM Line	-600	-680	80

11.	F.H. #46, E. of Pumphouse 31	-600	-580	-20*
12.	At Tank 38 (S750) 12" DFM Line	-665	-720	55
13.	F.H. #462, SW. of Tank 38	-490	-470	-20*

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of the test current.

AD-A119 019 PACIFIC CORROSION RESEARCH INC HUNTINGTON BEACH CA F/G 13/8
A-E SERVICES TO PERFORM A CATHODIC PROTECTION SURVEY OF THE BUL--ETC(U)
JUN 82 N62742-81-C-0006

UNCLASSIFIED NL

5 OF 5
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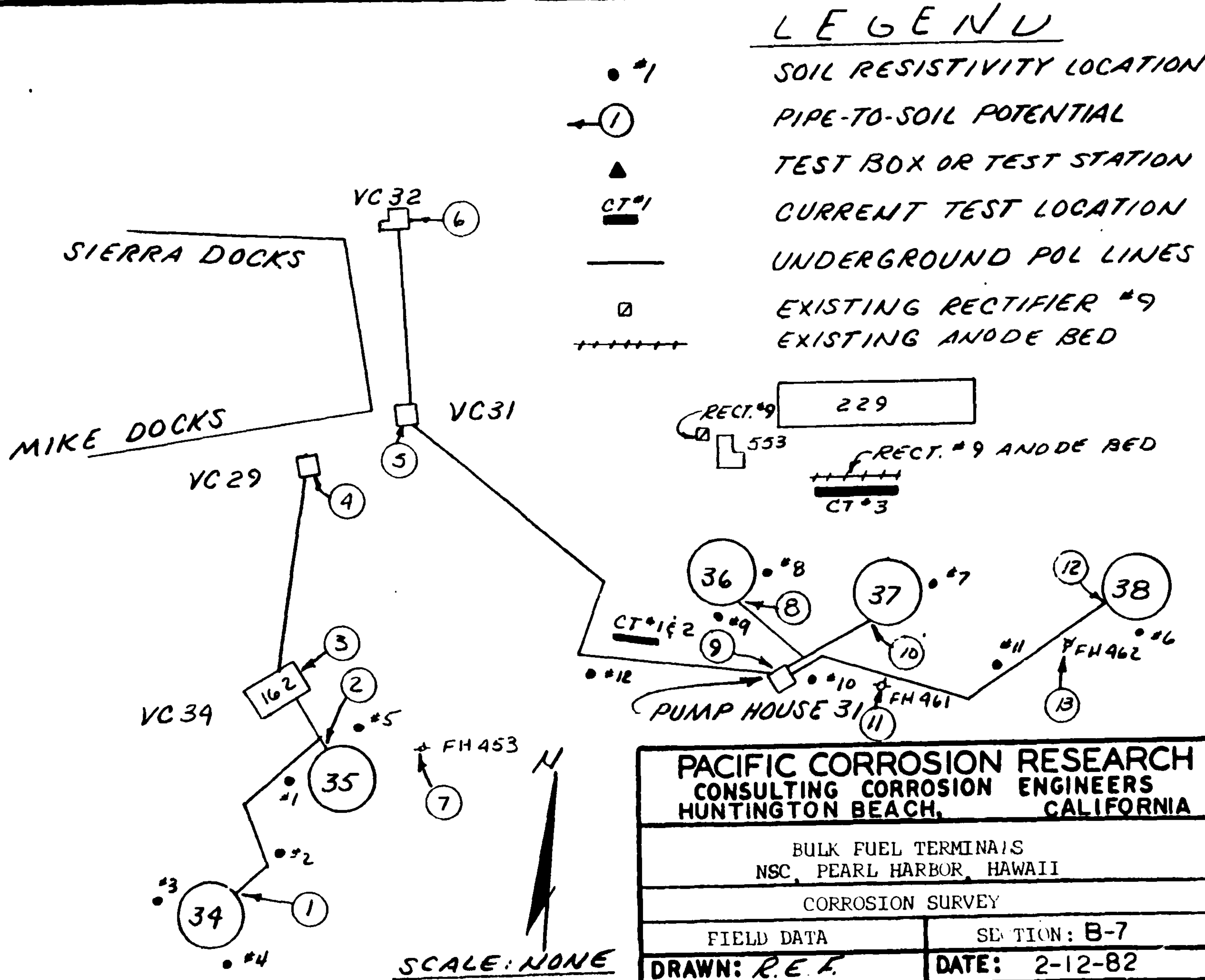
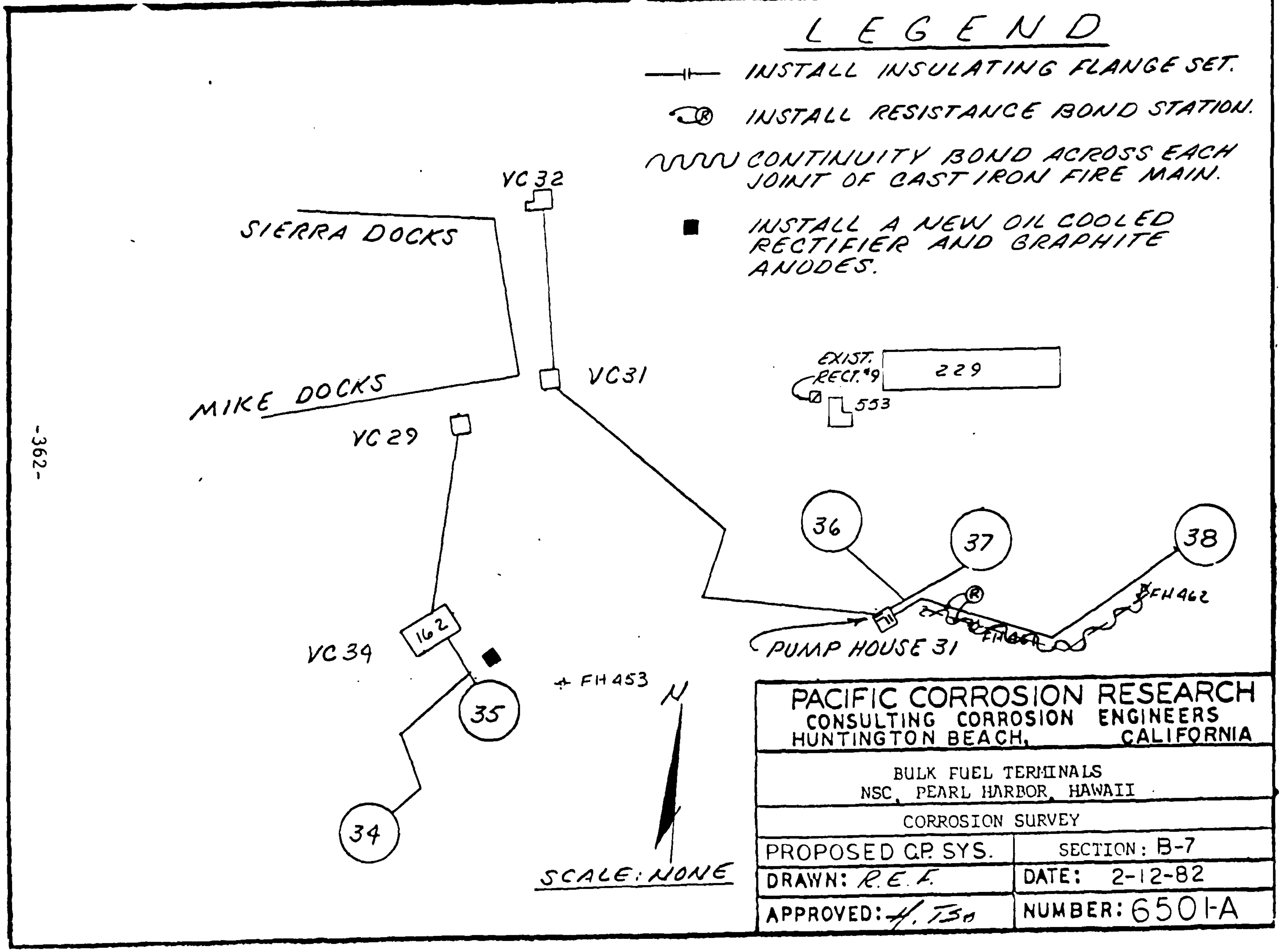


PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: B-7
DRAWN: R.E.F.	DATE: 2-12-82
APPROVED: H. Tso	NUMBER: 6501


LEGEND
INSTALL INSULATING FLANGE SET.
INSTALL RESISTANCE BOND STATION.
CONTINUITY BOND ACROSS EACH JOINT OF CAST IRON FIRE MAIN.
INSTALL A NEW OIL COOLED RECTIFIER AND GRAPHITE ANODES.
VC 32
SIERRA DOCKS
VC31
MIKE DOCKS
VC 29
EXIST. RECT. #9
229
553
36
37
38
FH 462
PUMP HOUSE 31
162
VC 34
35
34
FH 453
N
SCALE: NONE
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA
BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII
CORROSION SURVEY
PROPOSED C.P. SYS.
SECTION: B-7
DRAWN: R.E.F.
DATE: 2-12-82
APPROVED:
NUMBER: 6501-A

SECTION B-8

POL LINES INSIDE THE PEARL HARBOR COMPLEX

FROM BUILDING 88 TO MIKE DOCKS

SECTION B-8

POL LINES INSIDE THE PEARL HARBOR COMPLEX

FROM BUILDING 88 TO MIKE DOCKS

SECTION B-8

SUMMARY

1. Conclusions:

Based on the field data obtained, the following conclusions are made:

A. The soil environment in Section B-8 can be classified as an area of moderate corrosion potential.

B. All existing insulators on the oil and air lines were checked and found to be effective.

C. The lube oil and the air lines of Section B-8 are not at a protective potential level.

D. It is indicated by the current tests that a protective current of less than 500 ma D.C. will be required to provide protection for the underground lube oil and air lines from Building 88 to Mike Docks.

2. Recommendations:

It is recommended that a new sacrificial anode system be installed in the area between Building 88 and Building 146. This system will consist of a test box and six (6) 4"x4"x60" 60 lb. prepackaged magnesium anodes.

SECTION B-8

POL LINES INSIDE THE PEARL HARBOR COMPLEX

FROM BUILDING 88 TO MIKE DOCKS

1. Description.

   A. Lines to be Protected:

      (1) Four 6" L.O. lines from Bldg. 88 to Mike Docks - Steel with X-Tru-Coat

      (2) 2½" Air line - Steel with X-Tru-Coat

   B. Existing Cathodic Protection System:

   A study of Construction Drawings (construction contract N62471-73-C-0694) revealed that the existing two 6" L.O. lines, two 4" L.O. lines and one 4" air line from Building 88 to Mike Docks were replaced with four 6" L.O. lines and one 2½" air line with X-Tru-Coated steel in 1975. A sacrificial anode system consisting of two test boxes and four 17 lb. magnesium anodes was designed to be installed in 1975 to provide protection for the replaced underground lines. No test boxes were found during this survey.

2. Field Work and Evaluation of Data.

   A. Soil Resistivity Measurements: Two sets of soil resistivity measurements were obtained at the locations shown in Table No. VIII-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	0	Severe
Medium	2,000 - 10,000	66	Moderate
High	10,000 - 30,000	34	Slight unless other factors are pronounced
Very High	Above - 30,000	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on underground metallic structures. Sixty-six percent of the measurements obtained were in the moderate category and thirty-four percent were in the slight category.

B. "As Found" Pipe-to-Soil Potentials: "As Found" pipe-to-soil potentials were obtained on both sides of the existing insulators on the 6" L.O. and the 2½" air lines in the valve pit in Building 88 and in the valve pit at the Mike Docks. The results of pipe-to-soil potentials indicated that these underground lines are not at a protective potential level. The results of these measurements are shown in Table No. VIII-B.

C. Current Tests: One current test was conducted in the area between Building 146 and Building 88. Six steel rods were installed south of Building 146 as a test anode bed. The negative wire from a test rectifier was connected to the 6" L.O. line on the protected side of the existing insulator in Building 88. The current used for this test was 280 ma D.C.. Pipe-to-soil potentials were obtained at the

same locations as "As Found" potentials. The results of this current test are shown in Table No. VIII-C.

Based on the current test conducted, the following results were observed:

(1) The existing insulators were checked and found to be effective.

(2) The existing magnesium anodes were not functioning properly. This may be the result of one of the following:

a. Smaller magnesium anodes were installed.

b. The magnesium anodes were installed in a dry environment such as in dry sand and/or in rocks under blacktop.

(3) The current demand for the underground L.O. and air lines will be less than 500 ma.

D. Inspection of Pipelines: An inspection of the POL lines of Section B-8 was made in a valve pit at the Mike Docks. The lube oil and air lines under the Mike Docks are steel pipe coated with X-Tru-Coat and are supported by hangers. The coating of these lines is in good condition.

E. Leak History: We were advised by the base fuel personnel that existing lines of Section B-8 were replaced in 1975 due to leaks. No leaks in the new lines have occurred or were found during this survey.

3. Conclusions.

Based on the field data obtained, the following conclusions are made:

A. The environment in Section B-8 can be classified as an area

of moderate corrosion potential.

B. The lube oil and air lines of Section B-8 are electrically isolated from the base fuel piping system. All existing insulators on these lines were checked and found to be effective.

C. The lube oil and the air lines of Section B-8 are not receiving full protection from the existing magnesium anodes.

D. It is indicated by the current test that a protective current of less than 500 ma D.C. will be required to provide protection for the underground lube oil and air lines from Building 88 to Mike Docks.

4. Recommendations.

From the results of this survey, it is recommended that a new sacrificial anode system be installed in the area between Building 88 and Building 146. This system will consist of six 4"x4"x60", 60 lb. prepackaged magnesium anodes, a test box and an anode watering system.

NOTE: The locations of the pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No. 6502.

The recommended C.P. system of Section B-8 is shown on PCR Drawing No. 6502-A.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982 | SHEET 1 OF 1

ACTIVITY AND LOCATION	BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII
PROJECT TITLE	CATHODIC PROTECTION SYSTEM CORROSION SURVEY, SECTION B-8
CONSTRUCTION CONTRACT NO	N62742-81-R-0006
ESTIMATED BY	H. TSO
STATUS OF DESIGN	☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ______
IDENTIFICATION NUMBER	
CATEGORY CODE NUMBER	
JOB ORDER NUMBER	

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
4"x4"x60" 60 LB. PREPACKAGED MAG ANODES	6	ea	225.00	1350.00	150.00	900.00	375.00	2250.00
CONCRETE TEST BOX/CAST IRON LID	1	ea	45.00	45.00	75.00	75.00	120.00	120.00
1" PVC CLASS 200, PLASTIC PIPE	70	ft	0.75	52.50	0.15	10.50	0.90	63.00
0.01 OHM SHUNTS	1	ea	7.50	7.50	7.50	7.50	15.00	15.00
SPLIT BOLTS	8	ea	1.05	8.40	4.50	36.00	5.55	44.40
TERRA TAPE	80	ft	0.23	17.60	0.08	6.40	0.30	24.00
HOSE CONNECTION ADAPTER	1	ea	7.50	7.50	7.50	7.50	15.00	15.00
COAL TAR ENAMEL (1 GALLON CAN)	1	ea	22.50	22.50	45.00	45.00	67.50	67.50
TRENCH	80	ft	-	-	4.50	360.00	4.50	360.00
SUBTOTAL				1511.00		1447.90		2958.90
10% MISC. MATERIALS & LABOR				151.00		144.00		295.00
SUBTOTAL				1662.00		1591.90		3253.90
30% CONSTRUCTION PROFIT				498.00		477.57		976.17
TOTAL				2160.60		2069.47		4230.07

S/N 0105-LF-010-1335
★ G.P.O.: 1979 689-016/4302

SECTION B-8

SOIL RESISTIVITIES

TABLE NO. VIII-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	20' N. of Building 88, W. side	7200	3800	3600
2.	100' E. of Rdg. #1, between Bldg. 88 and Bldg. 147	10400	12000	9000

SECTION B-8

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. VIII-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	6" Lube Oil line at Bldg. 88	
	Above ground side of Ins.	-490
	Below ground side of Ins.	-660
2.	6" Lube Oil line at Bldg. 88	
	Above ground side of Ins.	-490
	Below ground side of Ins.	-660
3.	2½" Air Line at Bldg. 88	
	Above ground side of Ins.	-490
	Below ground side of Ins.	-660
4.	6" Lube Oil line at Bldg. 88	
	Above ground side of Ins.	-490
	Below ground side of Ins.	-660
5.	6" Lube Oil line at Bldg. 88	
	Above ground side of Ins.	-490
	Below ground side of Ins.	-660
6.	All lines from Bldg. 88 in VC at Mike Dock (Unprotected side of Ins.)	-410

SECTION B-8

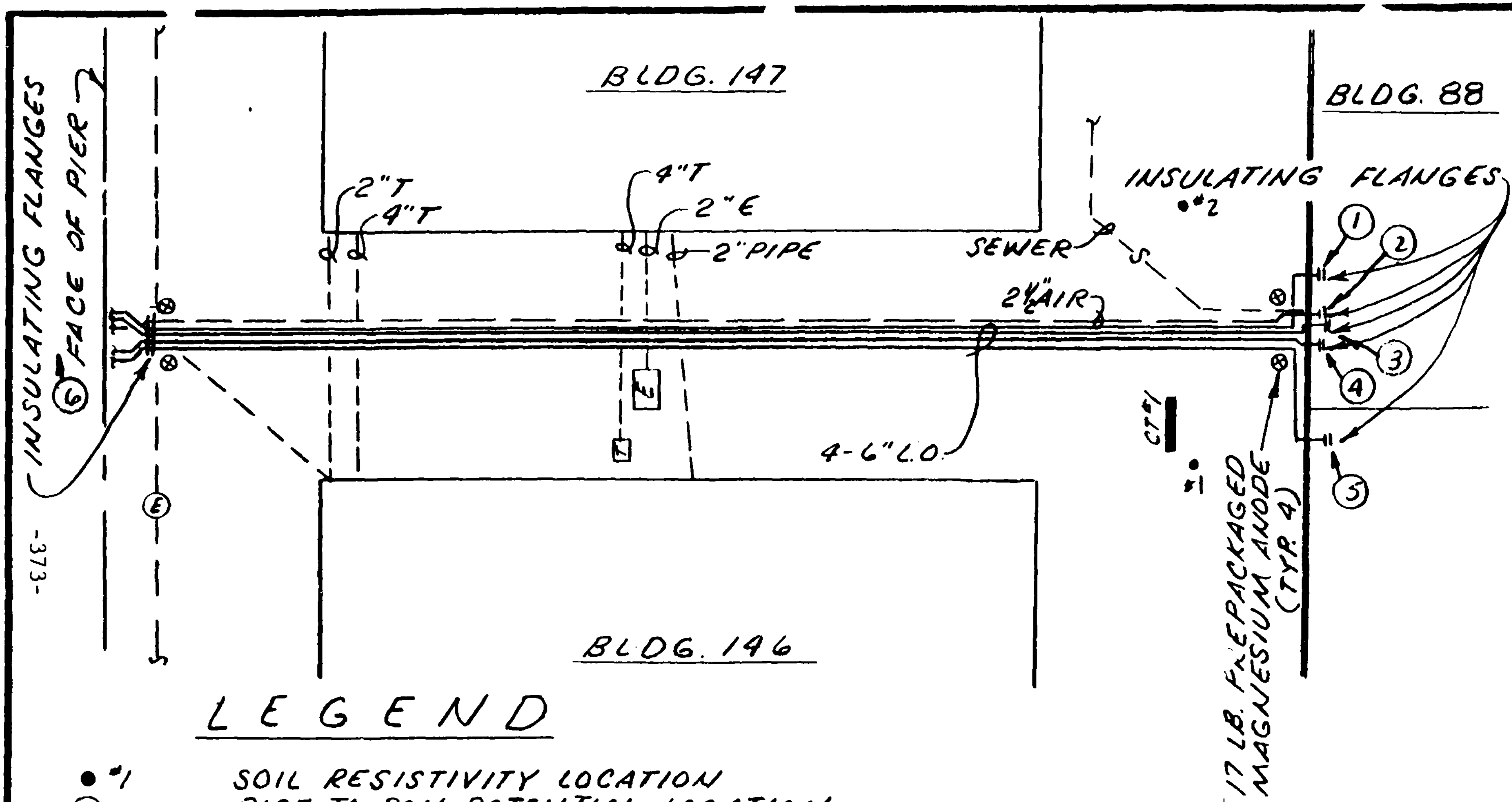
CURRENT TEST NO. 1

TABLE NO. VIII-C

Location:	Bldg. 88, Mike Dock
Anodes used for current test:	6 steel rods as temporary anodes.
Negative Connection:	Oil line at Bldg. 88.
Rectifier D.C. Output:	280 ma. D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	6" Lube Oil Line at Bldg. 88			
	Above ground side of Ins.	-490	-220	-270*
	Below ground side of Ins.	-660	-1280	620
2.	6" Lube Oil Line at Bldg. 88			
	Above ground side of Ins.	-490	-220	-270*
	Below ground side of Ins.	-660	-1280	620
3.	2½" Air line at Bldg. 88			
	Above ground side of Ins.	-490	-220	-270*
	Below ground side of Ins.	-660	-1280	620
4.	6" Lube Oil line at Bldg. 88			
	Above ground side of Ins.	-490	-220	-270*
	Below ground side of Ins.	-660	-1280	620
5.	6" Lube Oil line at Bldg. 88			
	Above ground side of Ins.	-490	-220	-270*
	Below ground side of Ins.	-660	-1280	620
6.	All lines from Bldg. 88 in VC at Mike Docks (Unprotected side of Insulator)	-410	-380	-30*

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of the test current.



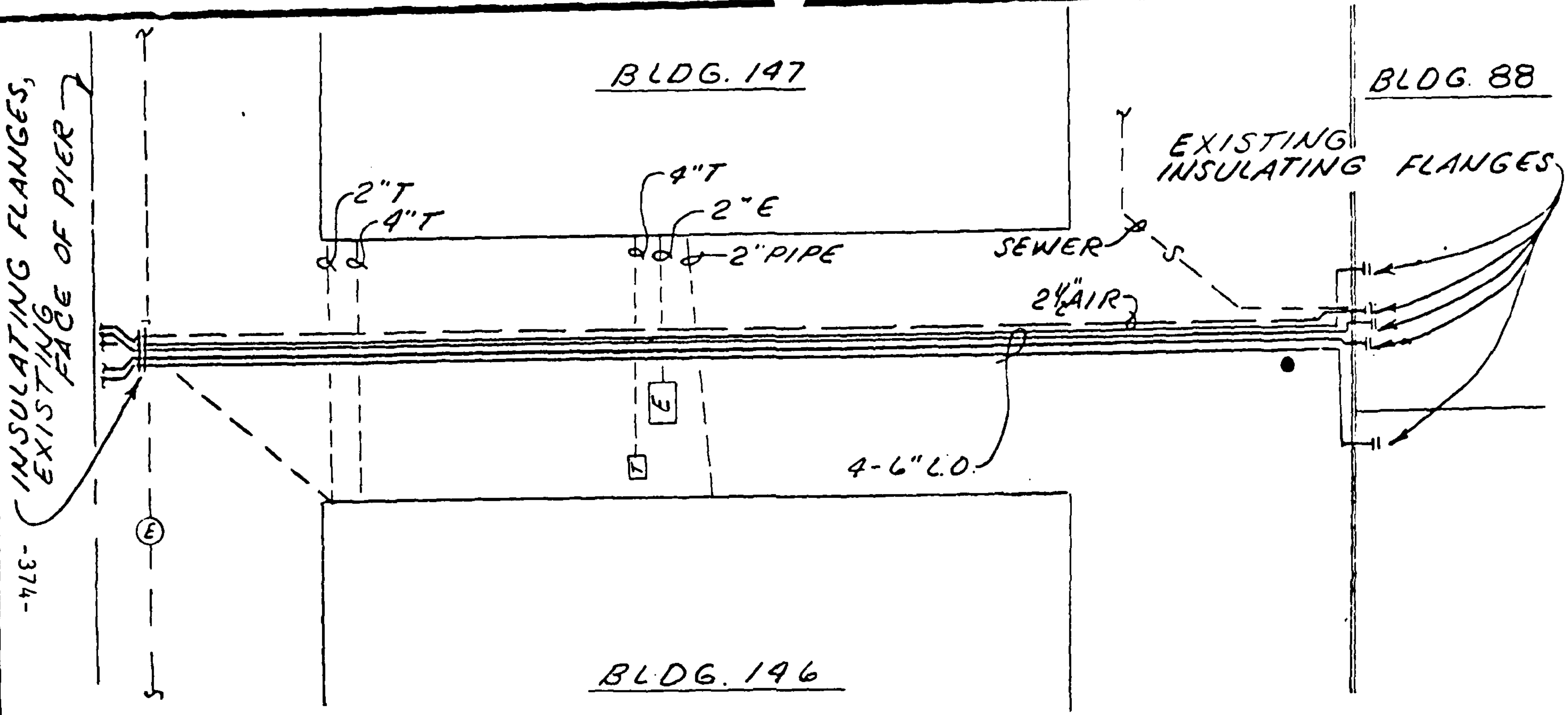
LEGEND

● #1	SOIL RESISTIVITY LOCATION
①→	PIPE-TO-SOIL POTENTIAL LOCATION
▬ CT#1	CURRENT TEST LOCATION
——	UNDERGROUND POL LINES
⊗	17 LB. PREPACKAGED MAGNESIUM ANODES WITHOUT TEST BOX (4)
—‖—	INSULATING FLANGE (10)

N →

SCALE: NONE

PACIFIC CORROSION RESEARCH **CONSULTING CORROSION ENGINEERS** **HUNTINGTON BEACH, CALIFORNIA**	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: B-8
DRAWN: R.E. F.	**DATE:** 2-12-82
APPROVED: [illegible]	**NUMBER:** 6502



LEGEND

• INSTALL A NEW TEST BOX AND INSTALL PREPACKAGED MAGNESIUM ANODES.

N →

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED CP. SYS.	SECTION: B-8
DRAWN: R.E. F.	DATE: 2-12-82
APPROVED: H. Tso	NUMBER: 6502-A

SECTION B-9

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE 12" DFM LINE FROM VC-20 TO A POINT NORTHWEST

OF BUILDING 599 ON BAKER DOCKS

SECTION B-9

POL LINES INSIDE THE PEARL HARBOR COMPLEX

INCLUDING THE 12" DFM LINE FROM VC-20 TO A POINT NORTHWEST

OF BUILDING 599 ON BAKER DOCKS

SECTION B-9

SUMMARY

1. Conclusions:

Based on the field data obtained, the following conclusions are made:

A. The environment in Section B-9 can be classified as an area of moderate to severe corrosion potential.

B. The POL lines of Section B-9 are not at a protective potential level.

C. The existing four sacrificial anode beds do not provide adequate protective current for the POL lines of Section B-9.

D. Test Box #11 and one 17 lb. prepackaged magnesium anode was found to be removed by a construction contractor during this survey.

E. The POL lines of Section B-9 are electrically continuous with the sheet piles of Merry Point Landing.

F. An insulator, as called for on the original design, was found to be installed above ground on the 12" DFM line before it enters Baker Docks. No insulator was found or installed on the 12" DFM line at a point of entry at the Mike Docks. This insulator was also called for on the original design.

G. The existing cathodic protection system for the protection of the sheet piles at Merry Point Landing was found to be functioning unsatisfactorilty.

H. The cast iron water line in VC-20 is not electrically continuous with the POL lines and the sheet piles in Merry Point Landing.

I. The current requirement will not be high if the 12" DFM line is isolated at a point where this line enters Mike Docks.

2. Recommendations:

A. An insulator should be installed on the 12" DFM line at a point entering Mike Docks.

B. The damaged coating areas of the 12" DFM line from Mike Docks to VC-20, as mentioned above, should be repaired by the construction contractor.

C. One 17 lb. prepackaged magnesium anode and a test box should be reinstalled at the existing Test Box #11 location by the construction contractor.

D. Based on the results of the preliminary checkout of the existing cathodic protection system for the sheet piles at the Merry Point Landing, the following recommendations are made:

(1) The D.C. capacity of each rectifier should be increased.

(2) The air cooled rectifiers should be replaced with oil cooled rectifiers.

(3) Additional anodes should be added and installed on both land and ocean anode beds. These anodes should be installed at various depths.

(4) The cast iron main in the area adjacent to the Merry Point Landing should be bonded with a No. 8 TW stranded copper cable. A resistance bond station should be installed between the sheet piling system and the cast iron water main near Mike Docks.

(5) A continuity bond should be made on the sheet piling system by bonding together each sheet pile with a No. 4 AWG stranded copper cable.

(6) A resistance bond station should be installed at the following locations:

a. Between the sheet piles and the new air line.

b. Between the sheet piles and the new steam line.

c. Between the sheet piles and the existing POL lines.

SECTION B-9

POL LINES INSIDE THE PEARL HARBOR COMPLEX INCLUDING THE 12" DFM LINE FROM VC-20 TO A POINT NORTHWEST OF BUILDING 599 ON BAKER DOCKS

1. Description.

A. Lines to be Protected:

(1) From VC-20 to East End of Baker Docks

12" DFM Line - Underground Steel with X-Tru-Coat

(2) From VC-20 to Mike Docks

12" NSFO Line - Underground Steel with X-Tru-Coat

(3) Under Baker Docks

6", 10" and 12" DFM Lines - Steel with X-tru-Coat

B. Existing Cathodic Protection Systems:

A study of Construction Drawings (NAVFAC DWG. NO. 7008521, 7008523, and 7008571) revealed that the 12" POL lines from VC-20 to Mike Docks and Baker Docks were replaced with X-Tru-Coated steel pipe in 1975. A cathodic protection system was designed and installed. This system consisted of four 17 lb. prepackaged magnesium anodes and four test boxes. An insulating flange was called for on the plans and was to be installed on the 12" POL line at each of the two locations where the line enters Mike Docks and Baker Docks.

(1) Test Box #11: This test box is located 22' west of VC-20. One 17 lb. prepackaged magnesium anode was installed in 1975. The test box and one anode were found to be torn out by construction work done in order to install a new steam and air line in this area.

(2) <u>Test Box #12</u>: This test box is 22' south of VC-20. One 17 lb. prepackaged magnesium anode was installed in 1975.

(3) <u>Test Box #13</u>: This test box is located 56' south of VC-20. One 17 lb. prepackaged magnesium anode was installed in 1975.

(4) <u>Test Box #14</u>: This test box is located 116' south of VC-20. One 17 lb. prepackaged magnesium anode was installed in 1975.

The anode bed open circuit potential and current output measurements of each anode bed were obtained at each test box. The results of these measurements are shown on Table No. XXII under Section E-2.

2. <u>Field Work and Evaluation of Data</u>:

A. <u>Soil Resistivity Measurements</u>: A total of four sets of soil resistivity measurements were obtained at representative locations shown in Table No. XIV-A. The result of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	42	Severe
Medium	2,000 - 10,000	50	Moderate
High	10,000 - 30,000	8	Slight unless other factors are pronounced
Very High	Above - 30,000	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on underground metallic structures. Forty-two percent of the measurements obtained were in the severe category and fifty percent were in the medium or moderate category.

B. <u>"As Found" Pipe-to-Soil Potentials</u>: "As Found" pipe-to-soil potentials were obtained at various locations from VC-20 to Baker Docks. The results of these measurements indicate that the underground 12" NSFO line of Section B-9 is not at a protective potential level. The results of these measurements are shown in Table No. XIV-B.

C. <u>Current Tests</u>: One current test was conducted in the lawn area south of VC-20. This current test was conducted by using the anode bed of existing Rectifier "A" which was designed and installed to provide protection for the land side of the sheet piles at Merry Point Landing Pier. It was used as a temporary anode bed. During this test, the existing rectifier wire from the sheet piles to Rectifier "A" was disconnected and a new negative wire was made from the new test lead in Test Box #13 to the rectifier. The current used for this test was 16.5 amperes D.C.. The results of this test are shown in Table No. XIV-C.

Based on the data obtained from this test, the following conclusions are submitted:

(1) The underground 12" DFM line of Section B-9 is electrically continuous with the POL lines of Sections B-4, B-6 and B-7.

(2) An insulator was found to be installed on the 12" DFM line above ground on the east end of the

Baker Docks.

(3) The cast iron main in VC-20 was found to be electrically discontinuous with the 12" DFM line of Section B-9.

(4) The existing sacrificial anodes do not provide adequate protection for the underground 12" DFM line in Section B-9.

(5) The current demand for the underground 12" DFM line of this section will be minimized if the 12" DFM line is isolated at a point where the line enters Mike Docks.

D. Existing Cathodic Protection System for the Sheet Piles at Merry Point Landing: The sheet piles at Merry Point Landing, located between the Baker Docks and the Mike Docks, was originally designed to be protected by an impressed current cathodic protection system. The installed system consists of two air cooled rectifiers (A & B), seven 2"x60" high silicon iron anodes and four 3"x60X graphite anodes. The land side of the sheet piles are to be cathodically protected by Rectifier "A" with the graphite anodes installed approximately 12' deep and 6' east of the sheet piles. For the protection of the ocean side of the sheet piles, seven 3"x60" high silicon iron anodes were mounted on the wood piles approximately 6' under the sea water level. This system was designed in 1977 and installed in 1979.

We were advised that this system has not been checked out and set-in-operation. We were requested by Mr. Fred Nakamura, Project Design Engineer, Code 102, to conduct a pre-

liminary checkout during this survey. The following work was performed:

(1) Natural Pipe-to-Soil Potentials and Pile-to-Seawater Potentials.

a. Natural Pile-to-Soil Potentials: Natural pile-to-soil potentials were obtained on the land side of the sheet piles with a copper-copper sulphate reference electrode half cell placed 18" off the sheet piles in a straight line at 10" intervals from Mike Docks to Baker Docks. These measurements were obtained with the existing Rectifiers "A" & "B" turned "off".

b. Natural Pile-to-Seawater Potentials: Natural pile-to-seawater potentials were obtained on the ocean side of the sheet piles with a copper-copper sulphate reference electrode half cell submerged 12" off the sheet piles and 6" below the water surface at two locations. These measurements were obtained with existing Rectifiers "A" and "B" turned "off".

The results of these measurements are shown in Table No. XVI-D. It was found that all potentials obtained were more negative than -550 mv. When a measurement is taken with a copper-copper sulphate reference electrode half cell, a potential of -550 mv is the normally accepted non-corroding potential of a steel sheet pile. Potentials which are more negative than -550 mv are indicative of either corrosion activity taking place on the steel sheet piles or protective

current being provided to the steel sheet piles by other cathodic protection systems.

(2) Current Tests.

a. Current Test No. 1 - This current test was conducted on the land side of the sheet piles. Pile-to-soil potentials were obtained at the same locations as the "As Found" potentials with the existing Rectifier "A" "off" and "on". During this test, Rectifier "A" was set at a tap setting 1 (coarse) - 3 (fine), operating at 4.5 volts and 26.5 amperes D.C.. The results of these measurements are shown in Table No. XIV-E.

b. Current Test No. 2 - This current test was conducted with the same anode bed configuration and negative connection as Current Test No. 1. During this test, the tap setting of Rectifier "A" was changed from 1 (coarse) - 3 (fine) to a new tap setting of 1 (coarse) - 4 (fine), providing 7.5 volts and a maximum current of 47 amperes D.C.. The results from these measurements are shown in Table No. XIV-F.

c. Current Test No. 3 - This current test was conducted on the ocean side of the sheet piles. Pile-to-seawater potentials were obtained at the same locations as the "As Found" potentials with the existing Rectifier "B" turned "off" and "on". During this test, Rectifier "B" was

set at a tap setting of 1 (coarse) - 5 (fine), operating at 11.75 volts and 35 amperes D.C.. The results of these measurements are shown in Table No. XIV-G.

Based on the data obtained from these tests, the following is submitted:

(i) Rectifier "A" as designed does not provide adequate protection for the land side of the sheet piles. As can be seen from Current Test No. 2, Table No. XIV-F, some areas of the sheet piles were not receiving full cathodic protection even if a maximum current of 47 amperes had been provided by Rectifier "A". (Note: Rectifier "A" has a D.C. capacity of 50 volts and 60 amperes. It was found that the current output will exceed its maximum capacity if the tap setting is increased from 1 - 3 to 1 - 4).

(ii) Rectifier "B" as designed, which has the same D.C. capacity as Rectifier "A", does not have an adequate current capacity as can be seen from Current Test No. 3, Table No. XIV-G. The sheet piles on the ocean side are not at a protective potential level. It is our professional opinion that the current demand for protection on the ocean side of the sheet piles will be almost double the current demand for the land side of the sheet piles.

(iii) The sheet piles were found to be electrically continuous with the POL lines under the Mike Docks and the Baker Docks.

E. Inspection of Pipelines: The underground X-Tru-Coated POL lines from Mike Docks to VC-20 was exposed due to a new installation of a new 6" steam line, a 6" air line and a cast iron water line in this area. The coating of the POL lines was found to be badly damaged by the construction work. Existing Test Box #11 and one 17 lb. prepackaged magnesium anode were removed by the construction contractor. These discrepancies were reported to Mr. Jim Gammon, Superintendent of the Fuel Department, on December 11, 1981.

F. Leak History: There were no leaks reported on this section of POL lines by the base fuel personnel.

3. Conclusions.

Based on the field data obtained, the following conclusions are drawn:

A. The environment in Section B-9 can be classified as an area of moderate to severe corrosion potential.

B. The POL lines of Section B-9 are not at a protective potential level.

C. The existing four sacrificial anode beds doe not provide adequate protective current for the POL lines of Section B-9.

D. Test Box #11 and one 17 lb. prepackaged magnesium anode was found to be removed as meantioned above by a construction contractor.

E. The POL lines of Section B-9 are electrically continuous with the sheet piles of Merry Point Landing.

F. An insulator, as called for on the original design, was found to be installed above ground on the 12" DFM line before it enters Baker Docks. No insulator was found or installed on the 12" DFM line at a point of entry at the Mike Docks. This insulator was also called for on the original design.

G. The existing cathodic protection system for the protection of the sheet piles at Merry Point Landing was found to be functioning unsatisfactorilty.

H. The cast iron water line in VC-20 is not electrically continuous with the POL lines and the sheet piles in Merry Point Landing.

I. The current requirement will not be high if the 12" DFM line is isolated at a point where this line enters Mike Docks.

4. Recommendations.

A. An insulator should be installed on the 12" DFM line at a point entering Mike Docks.

B. The damaged coating areas of the 12" DFM line from Mike Docks to VC-20 as mentioned above should be repaired by the construction contractor.

C. One 17 lb. prepackaged magnesium anode and a test box should be reinstalled at the existing Test Box #11 location by the construction contractor.

D. Based on the results of the preliminary checkout of the existing cathodic protection system for the sheet piles at the Merry Point Landing, the following recommendations are made:

(1) The D.C. capacity of each rectifier should be increased.

(2) The air cooled rectifiers should be replaced with oil cooled rectifiers.

(3) Additional anodes should be added and installed on both land and ocean anode beds. These anodes should be installed at various depths.

(4) The cast iron main in the area adjacent to the Merry Point Landing should be bonded with a No. 8 TW stranded copper cable. A resistance bond station should be installed between the sheet piling system and the cast iron water main near Mike Docks.

(5) A continuity bond should be made on the sheet piling system by bonding together each sheet pile with a No. 4 AWG stranded copper cable.

(6) A resistance bond station should be installed at each of the following locations:

a. Between the sheet piles and the new air line.

b. Between the sheet piles and the new steam line.

c. Between the sheet piles and the existing POL lines.

NOTE: The locations of pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No. 6503.

The recommended C.P. system for Section B-9 is shown on PCR Drawing No. 6503-A.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982 | SHEET 1 OF 1

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM CORROSION SURVEY, SECTION B-9

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
INSULATOR FLANGE SET	1	ea	45.00	45.00	75.00	75.00	120.00	120.00
RESISTANCE BOND STATIONS	3	ea	150.00	450.00	150.00	450.00	300.00	900.00
COAL TAR ENAMEL (1 GALLON CAN)	1	ea	22.50	22.50	45.00	45.00	67.50	67.50
SUBTOTAL				517.50		570.00		1087.50
10% MISC. MATERIALS & LABOR				51.00		59.00		108.00
SUBTOTAL				568.50		627.00		1195.50
30% CONSTRUCTION PROFIT				170.55		188.10		358.65
TOTAL				739.05		815.10		1554.15

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

SECTION B-9

SOIL RESISTIVITIES

TABLE NO. XIV-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	S of Bldg. 827	2300	2000	2000
2.	NE of Bldg. 346	14000	5200	4400
3.	NE of Bldg. 68	3400	2000	1080
4.	S of VC-20	4000	3600	800

SECTION B-9

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. XIV-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	12" DFM line, VC-20	-730
2.	10" C.I. Water Line, VC-20	-560
3.	TB. #11	Broken Test Lead
4.	TB. #12	-690
5.	TB. #13	-570
6.	TB. #14	-630
7.	12" DFM Line near Rectifiers	
	Ground side of Ins.	-680
	Dock side of Ins.	-690

SECTION B-9

CURRENT TEST NO. 1

TABLE NO. XIV-C

Location:	South of VC-20.
Anodes used for current test:	Anode bed of existing Rectifier "A"
Negative Connection:	To test lead in Test Box #13.
Rectifier D.C. Output:	16.5 Amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	12" DFM Line, VC-20	-730	-920	180
2.	10" C.I. Water, VC-20	-560	-530	-30*
3.	Test Box #12	-690	-1050	360
4.	Test Box #13	-570	-930	260
5.	Test Box #14	-630	-870	260
6.	12" DFM Line near Rectifiers			
	Ground side of insulator	-680	-1100	420
	Dock side of insulator	-970	-1110	140
7.	DFM line, VC-21	-680	-820	140

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION B-9

"AS FOUND" POTENTIALS

EXISTING CATHODIC PROTECTION SYSTEM LAND AND OCEAN SIDES OF THE SHEET PILES

Rdg. No.	Half Cell Locations (18" E. of Sheet Piles)	"As Found" Potentials (mv)
A.	LAND SIDE OF SHEET PILES	
	1. 5' S. of Mike Docks	-550
	2. 15' S. of Mike Docks	-560
	3. 25' S. of Mike Docks	-690
	4. 35' S. of Mike Docks	-695
	5. 45' S. of Mike Docks	-695
	6. 55' S. of Mike Docks	-700
	7. 65' S. of Mike Docks	-660
	8. 75' S. of Mike Docks	-660
	9. 85' S. of Mike Docks	-665
	10. 95' S. of Mike Docks	-660
	11. 105' S. of Mike Docks	-670
	12. 115' S. of Mike Docks	-685
	13. 125' S. of Mike Docks	-675
	14. 135' S. of Mike Docks	-620
	15. 145' S. of Mike Docks	-650
B.	OCEAN SIDE OF SHEET PILES	
	1. 15' N. of Baker Docks	-700
	2. 30' N. of Baker Docks	-695

SECTION B-9

CURRENT TEST NO. 1

EXISTING CATHODIC PROTECTION SYSTEM LAND SIDE OF SHEET PILES

TABLE NO. XIV-E

Location: Merry Point Landing.

Anodes used for current test: Four 3"x60" graphite anodes.

Rectifier Unit: Rectifier "A"

Tap Setting: 1 (coarse) - 3 (fine)

D.C. Output: 4.5 volts - 26.5 amperes D.C.

Rdg. No.	Half Cell Locations (18" E. of Sheet Piles)	Pile-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	5' S. of Mike Docks	-550	-570	20
2.	15' S. of Mike Docks	-560	-710	150
3.	25' S. of Mike Docks	-690	-745	55
4.	35' S. of Mike Docks	-695	-790	95
5.	45' S. of Mike Docks	-695	-820	125
6.	55' S. of Mike Docks	-700	-930	230
7.	65' S. of Mike Docks	-660	-770	110
8.	75' S. of Mike Docks	-660	-710	50
9.	85' S. of Mike Docks	-665	-900	235
10.	95' S. of Mike Docks	-660	-1100	550
11.	105' S. of Mike Docks	-670	-720	50
12.	115' S. of Mike Docks	-685	-770	85
13.	125' S. of Mike Docks	-675	-1585	910
14.	135' S. of Mike Docks	-620	-800	180
15.	145' S. of Mike Docks	-650	-795	145

16. 12" DFM Line

Ground side of Ins.	-740	-940	200
Dock side of Ins.	-695	-870	175

SECTION B-9

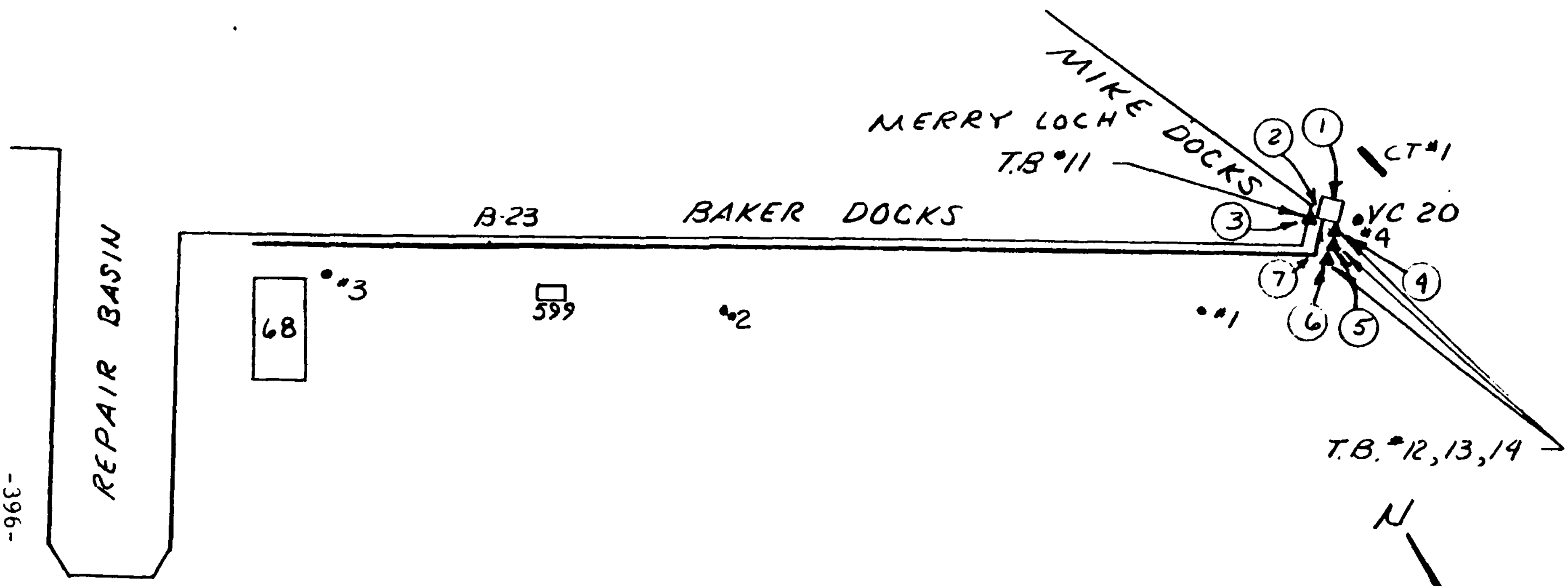
EXISTING CATHODIC PROTECTION SYSTEM OCEAN SIDE OF SHEET PILES

CURRENT TEST NO. 3

TABLE NO. XIV-G

Location:	Merry Point Landing.
Anodes used for current test:	Seven 3"x60" high silicon iron anodes.
Rectifier Unit:	Rectifier "B".
Tap Setting:	1 (coarse) - 5 (fine).
D.C. Output:	11.75 volts - 35 amperes D.C.

Rdg. No.	Half Cell Locations 12" Off Sheet Piles & 6" below water level	Pile-to-Seawater Potentials (mv)		
		I(Off)	I(On)	Change
1.	15' N. of Baker Docks	-700	-705	5
2.	30' N. of Baker Docks	-695	-705	10

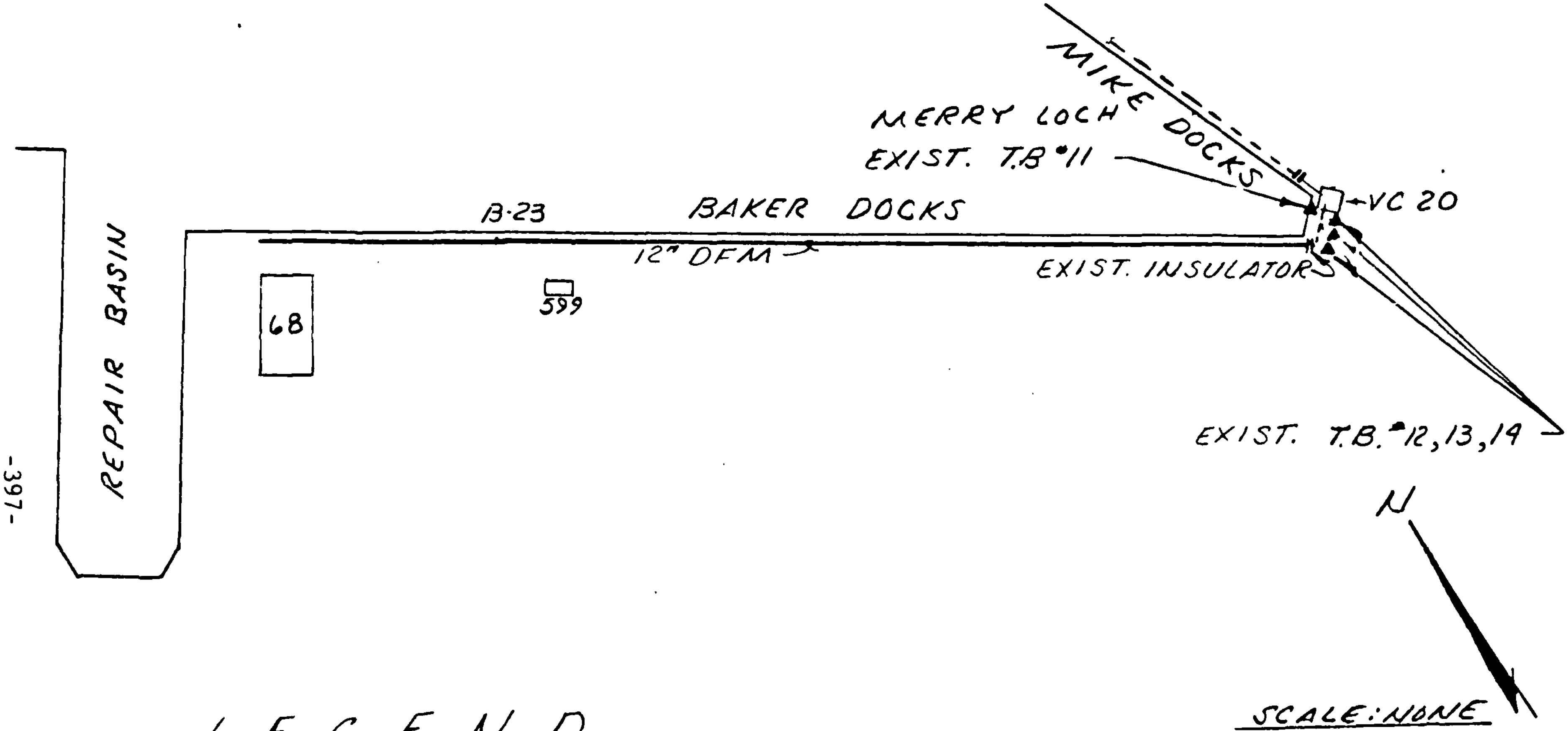


SCALE: NONE

LEGEND

- #1 SOIL RESISTIVITY LOCATION
- (1) PIPE-TO-SOIL POTENTIAL LOCATION
- CT #1 CURRENT TEST LOCATION
- ▲ TEST STATION OR TEST BOX
- UNDERGROUND, POL LINE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: B-9
DRAWN: REF	DATE: 2-12-82
APPROVED: H. TS.	NUMBER: 6503



LEGEND

INSTALL NEW INSULATING FLANGE SET

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED CP SYS.	SECTION: B-9
DRAWN: REF	DATE: 2-12-82
APPROVED: H. Ts.	NUMBER: 6503-A

SECTION B-10

POL LINES INSIDE THE PEARL HARBOR COMPLEX

FROM PUMPHOUSE 76, LOWER TANK FARM TO BUILDING 177 & BUILDING 149

SECTION B-10

SECTION B-10

POL LINES INSIDE THE PEARL HARBOR COMPLEX

FROM PUMPHOUSE 76, LOWER TANK FARM TO BUILDING 177 & BUILDING 149

SECTION B-10

SUMMARY

1. Conclusions:

Based on the field data obtained, the following is submitted:

A. The soil environment in Section B-1 can be classified as an area of moderate to severe corrosion potential.

B. The cast iron POL lines of Section B-10 are not at a protective potential level.

C. The existing sacrificial anode system does not provide adequate protection for this section of POL lines.

D. No insulators were found installed on the POL lines.

E. The cast iron POL lines were found not electrically continuous from section to section.

F. Approximately 33,000 sq. ft. of bare cast iron lines are to be considered for cathodic protection in Section B-10. Approximately 120 amperes D.C. will be required to provide a protective potential for these lines.

2. Recommendations:

It is recommended that an impressed current system be installed in Section B-10. This system will consist of three oil cooled rectifiers, thirty-two (32) 4"x40" graphite anodes and three resistance bond stations.

It is recommended that the cast iron POL lines with mechanical joints be bonded across each joint with No. 4 TW stranded copper cable from Pumphouse 76 to Power Plant #1, Building 149. We were advised by Mr. Jim Gammon that a replacement program is being planned to replace the existing cast iron POL lines. It is our professional opinion, if the Navy's decision is to replace the existing cast iron POL lines in the near future, that no cathodic protection system be provided for the existing C.I. POL lines. However, the new replacement POL lines should be steel with X-tru-Coat and considered for cathodic protection.

SECTION B-10

POL LINES INSIDE THE PEARL HARBOR COMPLEX FROM PUMPHOUSE 76 LOWER TANK FARM TO BUILDING 177 AND BUILDING 149

1. Description.

   A. Lines to be Protected:

      (1) From Pumphouse 76 to Power Plant #1

         a. 18" NSFO line - Bare cast iron

      (2) From Pumphouse 76 to Power Plant #2

         a. 14" NSFO line - Bare cast iron -abandoned.

      (3) From Pumphouse 76 to Power Plant #3

         a. 14" NSFO line - Bare cast iron -not in use

   B. Existing Cathodic Protection System.

   No cathodic protection system drawings were available at the time of this survey. The cast iron NSFO lines of Section B-10 were found to be protected by a sacrificial anode system. We were advised by Mr. John Kimi that there were test boxes with an unknown number of anodes installed along the POL lines. A majority of these test boxes were covered by asphalt. Only two test boxes were found.

      (1) Test Box #15 - This test box with an unknown number of anodes is located southwest of Pumphouse 76.

      (2) Test Box #16 - This test box with an unknown number of anodes is located south of Building 371 at Power Plant #3.

   The anode bed open circuit potential and the current output measurements of each anode bed were measured at each test box. The results of these measurements are shown in Table No. XXII, under Section E-2.

2. Field Work and Evaluation of Data.

A. Soil Resistivity Measurements: A total of seventeen sets of measurements were obtained at representative locations along the POL lines as shown in Table No. XV-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	39	Severe
Medium	2,000 - 10,000	57	Moderate
High	10,000 - 30,000	4	Slight unless other factors are pronounced
Very High	Above - 30,000	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on underground metallic structures. Thirty-nine percent of the measurements obtained were in the severe category and fifty-seven percent were in the medium or moderate category.

B. "As Found" Pipe-to-Soil Potentials: "As Found" pipe-to-soil potentials were obtained at each valve chamber throughout this section. The results of these measurements indicate that the POL lines of Section B-10 are not at a protective potential level. The results of these measurements are shown in Table No. XV-B.

C. Current Tests: Three current tests were conducted on the POL lines of Section B-10. Pipe-to-soil potentials were ob-

tained at the same locations as "As Found" potentials with the test rectifier "off" and "on".

(1) Current Test No. 1 - This current test was conducted in the area near Pumphouse 76. A short section of chain link fence on the south side of Pumphouse 76 was used as a temporary anode bed. The negative from a test rectifier was connected to the POL lines in Pumphouse 76. The current used for this test was 8.5 amperes D.C.. The results of this test are shown in Table No. XV-C.

(2) Current Test No. 2 - This current test was conducted with the same anode configuration and negative connection as Current Test No. 1. The current used for this test was increased to 27 amperes D.C.. The results of this test can be found in Table No. XV-D.

(3) Current Test No. 3 - This current test was conducted in the area south of VC-26. A short section of chain link fence south of VC-26 was used as a temporary anode bed. The negative wire from a test rectifier was connected to the POL lines in VC-26. The current used for this test was 18.5 amperes D.C.. The results of this test are shown in Table No. XV-E.

Based on the data obtained from the tests, the following is submitted:

a. The cast iron POL lines of Section B-10 were found not electrically continuous from section to section.
b. No insulators were found installed on the POL lines.
c. The current demand for the cast iron POL lines of Section B-10 will be high.

d. Existing sacrificial anode system does not provide adequate protection for the POL lines of Section B-10.

D. Leak History: We were advised that a leak in the 18" DFM line near Building 57, on Seventh Street, was found and repaired in 1980. The DFM line from VC-25 to Power Plants #2 and #3 were abandoned. It was found that the DFM line from the Pumphouse 76 to Power Plant #1, Building 149 are not presently being used.

3. Conclusions.

Based on the field data obtained, the following is submitted:

A. The results of soil resistivity measurements indicate that thirty-nine percent of the readings are in the severe category and fifty-seven percent are in the medium or moderate category. The environment in Section B-1- can be classified as an area of moderate to severe corrosion potential.

B. The cast iron POL lines of Section B-10 are not at a protective potential level.

C. The existing sacrificial anode system does not provide adequate protection for this section of POL lines.

D. No insulators were found installed on the POL lines.

E. The cast iron POL lines were found not electrically continuous from section to section.

F. The current requirement for the protection of the POL lines will be high. Approximately 33,000 sq. ft. of bare cast iron lines are to be considered for cathodic protection in Section B-10. Approximately 120 amperes D.C. will be required to provide a protective potential for these lines.

4. Recommendations.

Based on the results of the current tests and the calculations, an impressed current type of cathodic protection system will be most effective and economical for this section of POL lines. The high current demand makes it economically unfeasible to consider a sacrificial anode type of cathodic protection system for protection. The cost of a sacrificial anode system is approximately ten times the cost of an impressed current system of the same current output.

It is recommended that an impressed current system be installed in Section B-10. This system will consist of three oil cooled rectifiers, thrity-two 4"x40" graphite anodes and three resistance bond stations.

It is recommended that the cast iron POL lines with mechanical joints be bonded across with each joint with No. 4 TW stranded copper cable from Pumphouse 76 to Power Plant #1, Building 149. We were advised by Mr. Jim Gammon that a replacement program is being planned to replace the existing cast iron POL lines. It is our professional opinion, if the Navy's decision is to replace the existing cast iron POL lines in the near future, that no cathodic protection system be provided for the existing C.I. POL lines. However, the new replacement POL lines should be steel and coated with X-Tru-Coat and considered for cathodic protection.

NOTE: The locations of the pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No. 6504.

The recommended C.P. systems for Section B-10 are shown on PCR Drawing No. 6504-A.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION B-10

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) ______

JOB ORDER NUMBER

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
OIL COOLED RECTIFIERS	3	ea	1950.00	5850.00	600.00	1800.00	2550.00	7650.00
4''x40'' GRAPHITE ANODES	32	ea	210.00	6720.00	150.00	4800.00	360.00	11520.00
COAL COKE BREEZE	9600	lb	0.30	2880.00	0.08	768.00	0.38	3648.00
CONCRETE PADS	3	ea	150.00	450.00	600.00	1800.00	750.00	2250.00
1'' PVC CLASS 200, PLASTIC PIPE	1000	ft	0.75	750.00	1.15	150.00	0.90	900.00
#2 HMP STRANDED COPPER CABLE	500	ft	1.50	750.00	0.15	75.00	1.65	825.00
HOSE CONNECTION ADAPTERS	3	ea	7.50	22.50	7.50	22.50	15.00	45.00
CONCRETE TEST BOXES/CAST IRON LIDS	3	ea	45.00	135.00	75.00	225.00	120.00	360.00
RESISTANCE BOND STATIONS	3	ea	150.00	450.00	150.00	450.00	300.00	900.00
SPLIT BOLTS	40	ea	1.05	42.00	4.50	180.00	5.55	222.00
BUTYL TAPE	3	ea	37.50	112.50	45.00	135.00	82.50	247.50
RUBBER TAPE	9	ea	4.50	40.50	7.50	67.50	12.00	108.00
PLASTIC TAPE	9	ea	4.50	40.50	7.50	67.50	12.00	108.00
ALUMINO-THERMIC WELDS	14	ea	3.00	42.00	37.50	525.00	40.50	567.00
COAL TAR ENAMEL (1 GALLON CAN)	1	ea	22.50	22.50	45.00	45.00	67.50	67.50
TERRA TAPE	500	ft	0.23	115.00	0.08	40.00	0.31	155.00
TRENCH	500	ft	-	-	4.50	2250.00	4.50	2250.00

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 2 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM CORROSION SURVEY, SECTION B-10

STATUS OF DESIGN: [ ] PED [X] 30% [ ] 100% [ ] FINAL [ ] Other (Specify) ____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
BONDING OF CAST IRON PIPE	4800	ft	3.00	14400.00	10.50	50400.00	13.50	64800.00
ASPHALT SAW CUTTING	3800	ft	4.50	17100.00	6.00	22800.00	10.50	39900.00
SUBTOTAL				49922.50		86600.50		136523.00
10% MISC. MATERIALS & LABOR				4992.25		8660.05		13652.30
SUBTOTAL				54914.75		95260.55		150175.30
30% CONSTRUCTION PROFIT				16474.42		28578.17		45052.59
TOTAL				71389.17		123838.72		195227.89

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

SECTION B-10

SOIL RESISTIVITIES

TABLE NO. XV-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	S. of Bldg. 97 near Pumphouse	12000	5200	6800
2.	200' N. of Rdg. 1	2700	2000	1320
3.	200' NE. of Rdg. 2	14000	6200	5600
4.	N. of Bldg. I-44	3700	3600	2000
5.	N. of Bldg. 1358	7000	4400	1360
6.	200' SW. of VC-25	10000	8600	3200
7.	Near VC-25	600	620	680
8.	200' E. of VC-25	1500	2800	1120
9.	200' E. of Rdg. 8	2800	1600	760
10.	Near VC-26	2300	1000	960
11.	Near Bldg. 385 on 7th Street	9000	3200	2400
12.	200' N. of Rdg. 11	4800	3200	2400
13.	200' N. of Rdg. 12	1400	1400	1000
14.	Near VC-27	5000	4400	1680
15.	Near Fuel Tanks #1 & #2	1700	1200	920
16.	500' W. of VC-25	2900	3400	2000
17.	Near the Power Plant Bldg. 177	8000	10000	4400

SECTION B-10

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. XV-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	Pumphouse 76, all lines	-490
2.	Test Box 15, SW of Pumphouse 76	-510
3.	VC-25	-445
4.	VC-26	-500
5.	VC-27	-480
6.	VC at Power Plant Bldg. 177	-390
7.	Test Box #16, E. of Bldg. 371	-1300
8.	Fuel Tanks #1 & #2, S. of Bldg. 149	-480

SECTION B-10

CURRENT TEST NO. 1

TABLE NO. XV-C

Location:	Pumphouse 76.
Anodes used for current test:	Chain Link Fence.
Negative Connection:	POL line in Pumphouse 76.
Rectifier D.C. Output:	8.5 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Pumphouse 76, all lines	-490	-900	410
2.	Test Box #15	-510	-610	100
3.	VC-25	-415	-410	-5*
4.	VC-26	-510	-505	-5*
5.	VC-27	-440	-440	0
6.	VC at Power Plant Bldg. 177	-390	-390	0
7.	Test Box #16, E. of Bldg. 371	-1300	-1300	0
8.	Fuel Tanks #1 & #2, S. of Bldg. 149	-390	-390	0

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION B-10

CURRENT TEST NO. 2

TABLE NO. XV-D

Location:	Pumphouse 76.
Anodes used for current test:	Chain link fence.
Negative Connection:	Fuel Line in Pumphouse.
Rectifier D.C. Output:	17 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Pumphouse 76, all lines	-490	-1210	720
2.	Test Box #15, SW of Pumphouse 76	-510	- 705	195
3.	VC-25	-415	- 410	-5*
4.	VC-26	-510	- 505	-5*
5.	VC-27	-440	- 435	-5*
6.	VC at Power Plant, Bldg. 177	-390	- 385	-5*
7.	Test Box #16, E. of Bldg. 371	-1300	-1290	-10*
8.	Fuel Tanks #1 & #2, S. of Bldg. 149	-390	- 385	-5*

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION B-10

CURRENT TEST NO. 3

TABLE NO. XV-E

Location: VC-26.

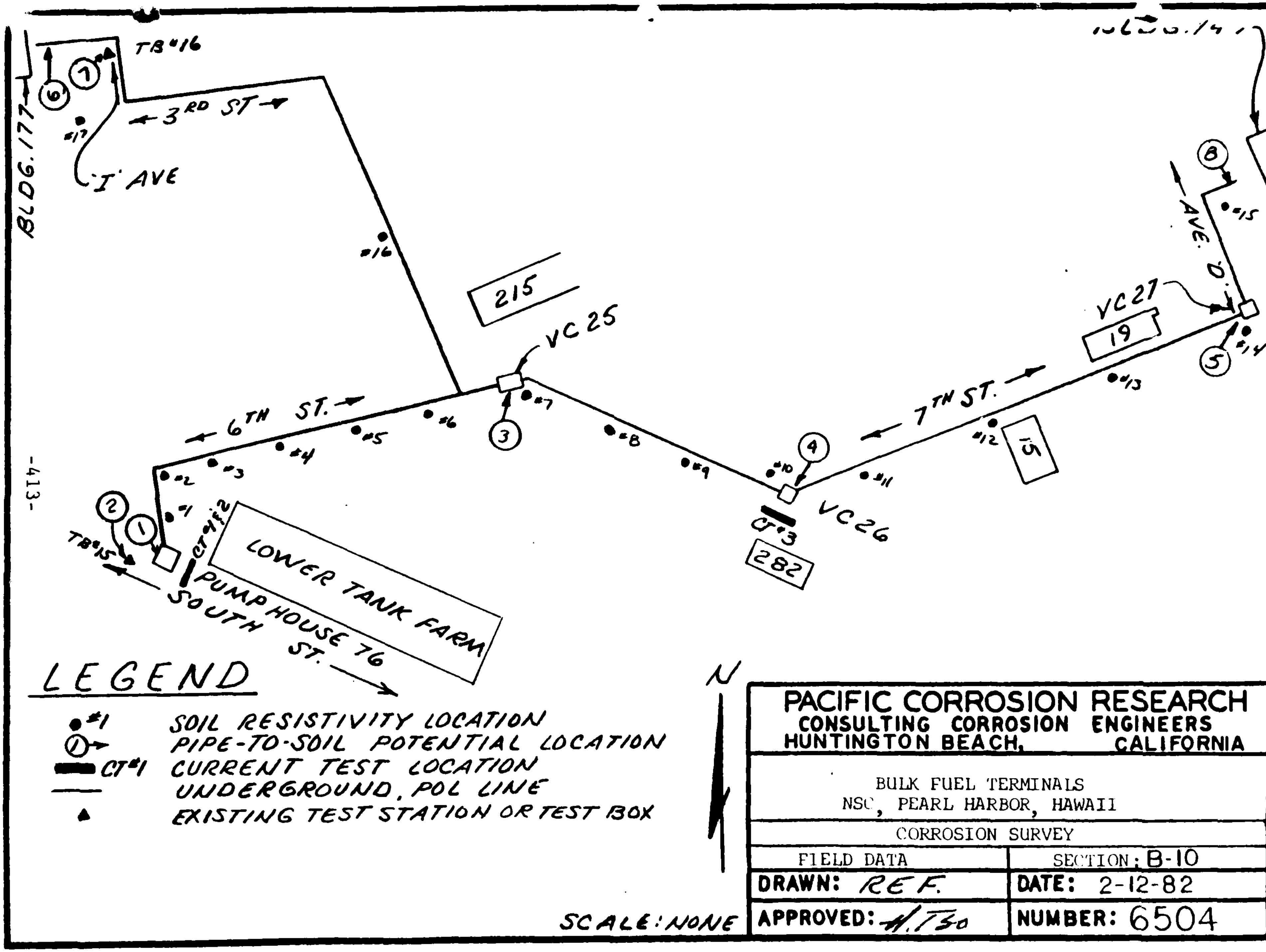
Anodes used for current test: Chain Link Fence.

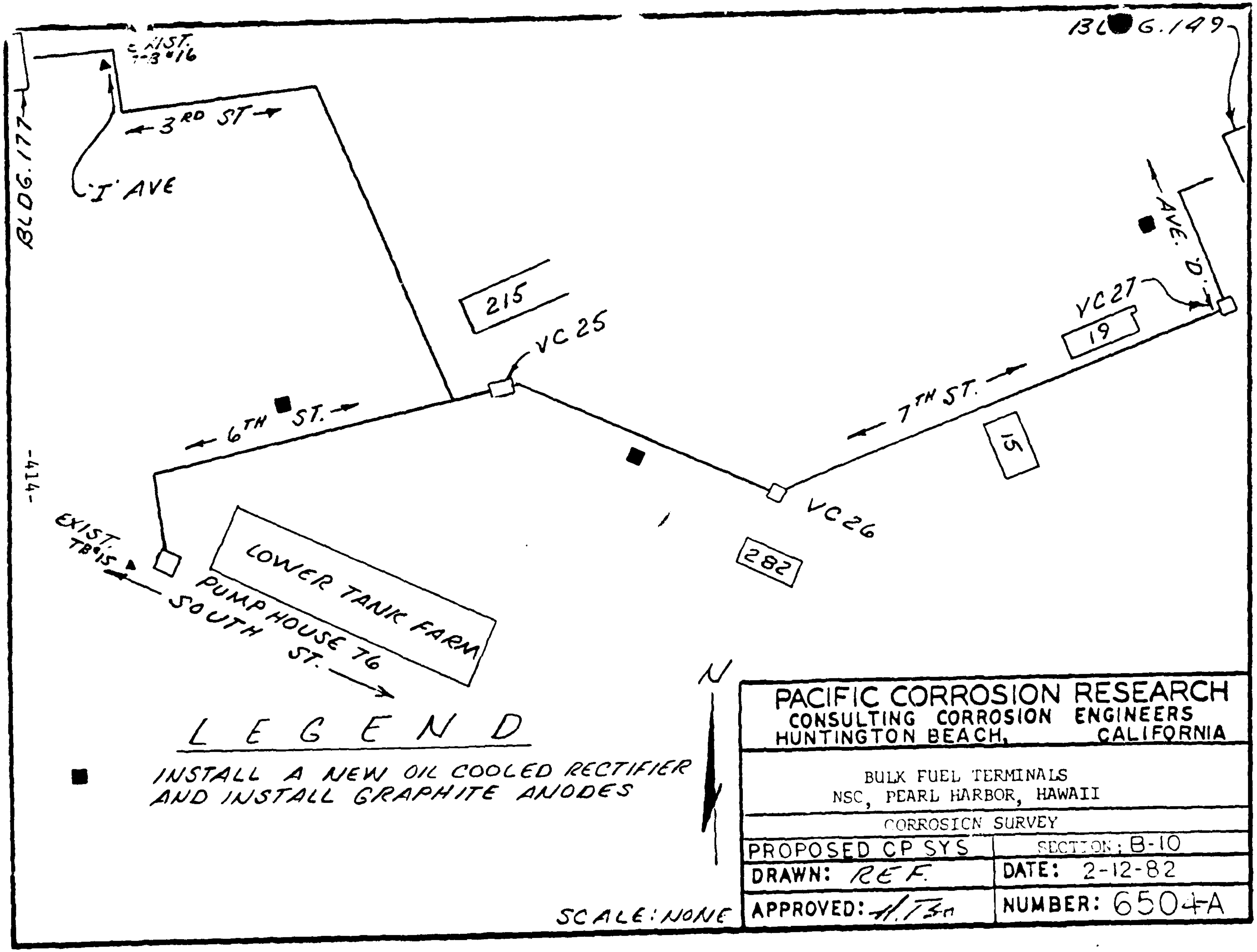
Negative Connection: Fuel Line at VC-26.

Rectifier D.C. Output: 8.5 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Pumphouse 76	-490	-485	-5*
2.	Test Box #15, SW of Pump-house 76	-510	-510	0
3.	VC-25	-425	-420	-5*
4.	VC-26	-500	-1100	600
5.	VC-27	-440	-440	0
6.	VC at Power Plant Bldg. 177	-390	-385	-5*
7.	Test Box #17, E. of Bldg. 371	-1300	-1300	0
8.	Fuel Tanks #1 & #2, S. of Bldg. 149	-390	-385	-5*

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.


BLDG. 177
TB #16
3RD ST
'I' AVE
#17
#16
215
VC 25
6TH ST.
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
#12
#13
#14
#15
TB #15
CT #2
LOWER TANK FARM
PUMPHOUSE 76
SOUTH ST.
CT #3
282
VC26
7TH ST.
15
19
VC27
AVE. 'D'
N
LEGEND
#1 SOIL RESISTIVITY LOCATION
PIPE-TO-SOIL POTENTIAL LOCATION
CT #1 CURRENT TEST LOCATION
UNDERGROUND, POL LINE
EXISTING TEST STATION OR TEST BOX
SCALE: NONE
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA
BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII
CORROSION SURVEY
FIELD DATA
SECTION: B-10
DRAWN: REF.
DATE: 2-12-82
APPROVED: H.T.
NUMBER: 6504


BLDG. 149
BLDG. 177
EXIST. T-3 #16
3RD ST
'I' AVE
215
VC 25
VC 27
AVE. 'D'
19
7TH ST.
15
6TH ST.
VC 26
282
EXIST. TB #15
LOWER TANK FARM
PUMPHOUSE 76
SOUTH ST.
N
LEGEND
INSTALL A NEW OIL COOLED RECTIFIER AND INSTALL GRAPHITE ANODES
SCALE: NONE
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA
BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII
CORROSION SURVEY
PROPOSED CP SYS
SECTION: B-10
DRAWN: REF.
DATE: 2-12-82
APPROVED: H.T.
NUMBER: 6504-A

MED

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